U. S. Bureau of Medicine & Surg.
Navy

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EPIDEMIOLOGY OF DISEASES OF MILITARY IMPORTANCE IN THE NETHERLANDS INDIES

INCLUDING THE IDENTIFICATION AND DISTRIBUTION OF ARTHROPODS OF MEDICAL IMPORTANCE

NAVMED 133

U.S. Bureau of medicine and Surgery

(This manual includes only the areas formerly under Dutch administration. It does not take into account Portuguese Timor, British New Guinea, and British Borneo)

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FOREWORD

The purpose of this manual is to present a summary of medical information concerning the Netherlands Indies as it pertains to epidemiology and other phases of preventive medicine. The bulk of the information has been obtained from the medical journals and other publications of the Netherlands Indies. The information recorded is the result of a perusal of about 5,000 pages of material and a more hasty study of several thousand additional pages.

The principal general sources have been the two fine Netherlands Indies medical journals, *Geneeskundig Tijdschrift voor Nederlandsch-Indië* and *Mededeelingen van den Dienst der Volksgezondheid in Nederlandsch-Indië*, the official organ of the Netherlands Indies Public Health Service. Much of the material on malaria and its transmission was derived from the monograph of Swellengrebel and Rodenwaldt, *Die Anophelen von Niederlandisch-Ostindien* supplemented by numerous more recent papers. Much of the entomological information comes from the pages of *Tijdschrift voor Entomologie.* Statistics in general come from the *Indisch Verslag*, the official statistical organ of the Netherlands Indies Government. The numerous other references to the literature which have been employed are given in the bibliography.

It is necessary to bear in mind that this manual is of necessity essentially a non-critical compilation although every effort has been made to check the accuracy and authenticity of the source papers. Because most of the information comes from the work of individuals who have many years' experience in the Netherlands Indies one feels definitely inclined to regard it as fundamentally sound and accurate.

Several publications and reports are available which would be of value as a supplement to this compilation.

Mosquito Atlas, Part II by Ross and Roberts contains many illustrations of medically important anophelines of this area. *Keys to the Anopheline Mosquitoes of the World*, by Russell, Rozeboom, and Stone contains keys for the identification of *Anopheles*. The excellent report compiled by Dr. I. Snapper for the Surgeon General's Office, United States Army, contains much valuable information. The text-book of de Langen and Lichtenstein contains useful information, primarily clinical. A translated edition by Dr. A. H. Hamilton is available.

The War Department's Technical Manual, *Emergency Food Plants and Poisonous Plants of the Islands of the Pacific*, prepared by Dr. E. D. Merrill, is the best available source of information on this subject.

Reference may be made also to Doris M. Cochran's *Poisonous Reptiles of the World* (Smithsonian Institution War Background Studies, Number 10) and to Dr. Raymond Kennedy's *Islands and Peoples of the Indies* (same series, Number 14).

In allocating space to various subjects emphasis has been placed on diseases of importance in operations and primarily those which are not normally encountered in temperate climates. As a result the greater part of the manual is devoted to malaria and other insect-borne diseases. Many things, such as nutritional deficiencies and diseases, of importance to the Indies have been purposely omitted because they are relatively unimportant from the standpoint of naval personnel and operations. Certain diseases such as leprosy, yaws, and the venereal diseases are extremely prevalent. However the space devoted to these has been much reduced because, as problems to naval personnel, they are no different in the Netherlands Indies than elsewhere.

Many individuals have rendered invaluable assistance in preparing this manual. Dr. Alan Stone, Division of Insect Identification, Bureau of Entomology and Plant

Quarantine, assisted in preparing the material on mosquitoes. Dr. Maurice T. James also of the Division of Insect Identification supplied notes on the muscoid flies of medical importance. Dr. E. A. Chapin, Curator of Insects, National Museum, arranged for laboratory space and other facilities. Dr. Paul Bartsch, Curator of Mollusks and Cenozoic Invertebrates, National Museum, prepared the notes on the molluscan intermediate hosts of human trematodes. Miss Doris M. Cochran, Curator of Herpetology, supplied information on the poisonous snakes, and Dr. E. Schwartz supplied information on rats. Dr. I. Snapper, Consultant, Division of Preventive Medicine, United States Army, made available his notes on skin diseases, leprosy, leptospirosis, as well as other information and bibliographic references. The bibliographic files of the Division of Zoology, Bureau of Animal Husbandry, were an invaluable source of references on parasites. Dr. H. Elishewitz, Naval Research Institute, has supplied information on ticks. Captain Paul W. Wilson (MC) USN; Captain T. J. Carter (MC) USN; Commander Omar J. Brown (MC) USN; Commander V. C. Tipton (MC) USNR; Lieut. Commander E. H. Hudson (MC) USNR; and Lieut. Commander E. M. Bingham (MC) USNR have read the manuscript in part or its entirety and have given valuable suggestions. Lieut. Commander D. F. Smiley (MC) USNR has assisted in the planning and compilation and has critically examined the entire manuscript. Mrs. E. K. Noice has checked the bibliography and geographical locations and has edited the entire manual. The statistical compilations have been made by Miss A. M. Danhakl.

D. S. Farner,
Ensign, H–V(S), USNR.

Bureau of Medicine and Surgery,
Division of Preventive Medicine,
Section of Epidemiology.

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Chapter I

INTRODUCTION

The Netherlands Indies are a sprawling chain of hundreds of volcanic islands extending for 3,000 miles from the Malay Peninsula eastward to include the western half of the island of New Guinea. The width of the archipelago is approximately 1,200 miles. The islands vary in size from small uninhabited volcanic rocks to the giant islands of Sumatra, Borneo, Java, and New Guinea. In the cases of Borneo, Timor, and New Guinea only the Dutch portions of these islands are to be considered in this report.

The climate of the Netherlands Indies is tropical, warm and oppressively humid. Because of the insular nature of the area generalizations except in the broadest sense are apt to be erroneous. Braak (1931) describes the climate as the "rainiest in the world." The entire archipelago is under the influence of the monsoon winds and much of the seasonal climatological changes are dependent on these winds. The transition between the monsoons occurs ordinarily in April and November with variation according to latitude. In the South the East Monsoon usually has begun by April whereas in the North the south and southeast winds are not prevalent until May. In the Lesser Soendas (Sundas), Java, Sumatra, and New Guinea the winds of the East Monsoon blow from the east and southeast whereas in Borneo, Celebes, and the Molukkas (Moluccas) the wind directions in the East Monsoon are south or southeast. During the West Monsoon wind directions are west-northwest and northwest on Java, East Sumatra, and the Lesser Soendas, and north, north-

FIG. I Principal Islands and Cities of the Netherlands Indies

east and northwest on New Guinea, Molukkas, and Celebes. The transition to the West Monsoon occurs in November. However, there is considerable variation due to latitudinal differences.

In Batavia the absolute maximum temperature is 38.8° C.; the absolute minimum is 18.3° C. In East Java, Lesser Soenda, Celebes, southern Molukkas, Timor, and Aroe there is a dry season associated with the East Monsoon in July and August which is somewhat cooler. In general it can be said that mean maximum temperatures vary from 28.8° C. to 32.6° C., depending on the time of year and the station. The mean minimum temperatures vary from 20.5° C. to 23.6° C. Temperature decreases about 2° C. per 1,000 feet increase in altitude.

Annual rainfall of 150 inches or more occurs in the mountains of Java, on the north coasts of Banka (Bangka) and Billiton, in the mountains of South and East Borneo, and at Ambon (Amboina) and Saparoea in the Molukkas. Jasaredja in Middle Java has the greatest annual rainfall, about 275 inches. Because of the importance of climatological factors, particularly rainfall, in malaria and filariasis control a more detailed discussion is given in Appendix G.

Geologic origin and history of the islands of the Netherlands Indies have resulted in a peculiarity in faunal geography. The eastern portion of the archipelago, including New Guinea, the Molukkas, Soela Islands, Aroe Islands, Tanimbar Islands, and Babar Islands, because of its recent continuity with Australia and its long isolation from Asia and the Asiatic islands possesses a characteristically Australian fauna (fig. 2). On the other hand the Greater Soenda Islands (Sumatra, Borneo, Celebes, and Java) and adjacent islands, as well as the Lesser Soenda Islands, because of their relatively recent continuity with the Asiatic mainland and their long isolation from the

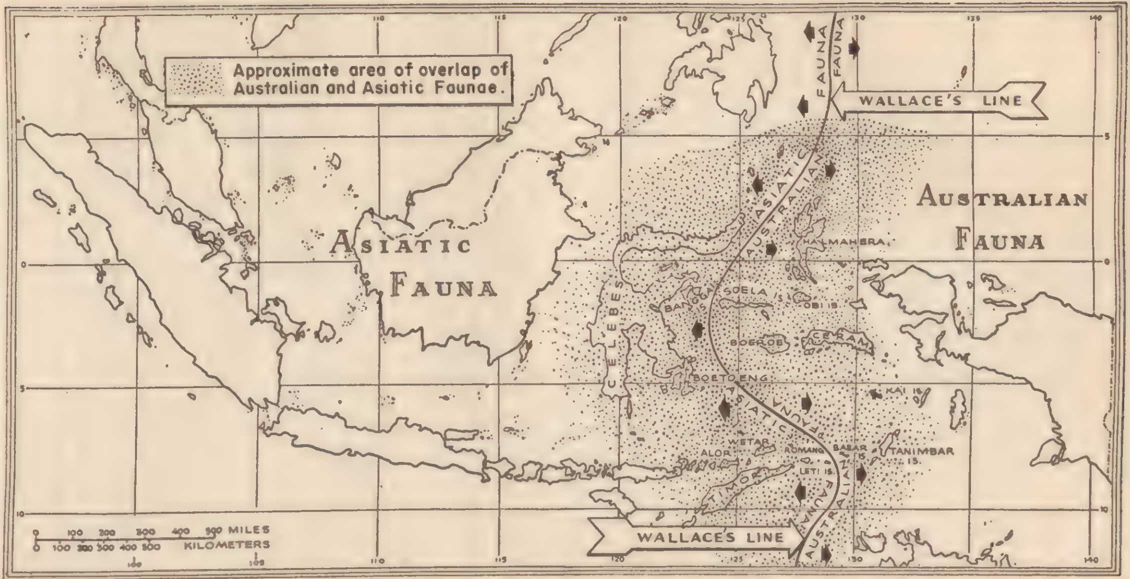

FIG.2 Faunal Regions of the Netherlands Indies . . . .

Australian Islands, are inhabited by typically Asiatic species. The boundary of these two faunal groups is usually regarded as coincident with a line passing from north to south between Halmahera Island and Celebes, between Soela and Banggai, and between Leti and Babar. This is known to zoogeographers as Wallace's line.[1] In the case of many species it is more accurate to speak of a transition zone extending from 120° to 130° east longitude in which there is an intermingling and gradual transition between the two faunae. Also there are certain hardy ubiquitous species whose distributions show no relationship to this concept and which cannot be assigned to any particular faunal group. An excellent example of such a species is *Aëdes aegypti* whose distribution is world-wide in the tropics and semitropics. Nevertheless the concept of Wallace's line is useful. It has ready application in the distribution of malaria vectors. For instance, the most important vector in New Guinea is *Anopheles punctulatus moluccensis*, an Australian species whose westward range extends only to Wallace's line, whereas in the western part of the archipelago the most important vector is the brackish-water breeder, *Anopheles sundaicus*, whose range extends eastward to Wallace's line. This characteristic distribution holds true for all of the important malaria vectors in the Netherlands Indies. Hence the type of control and precautionary measures to be employed must depend to a considerable degree on whether one is in the Australian or Asiatic Zone. Further applications of this are found in the distribution of *Wuchereria malayi* and its vectors as well as in the distribution of poisonous snakes and plants.

The population of the Netherlands Indies according to the 1930 census was 60,727,000. The population of Java and Madoera alone was about 42,000,000. The estimated

[1] The line of division proposed by Wallace, and hence in reality the true Wallace's Line, passed between Celebes and Borneo. In recent years it has become obvious that the more easterly line, as used here, is perhaps a more accurate division.

population in 1937 for the entire archipelago was about 65,000,000. It is therefore obvious that the population density varies tremendously from crowded agricultural Java to Borneo and New Guinea with their vast expanses of uninhabited jungles. These differences are amply illustrated in a tabulation of population by political subdivisions.

TABLE 1.—*Population and population density in the Netherlands Indies*

	Area in square miles	Population 1930	Population density inhabitants (square miles)
Java and Madoera	51,000	41,718,000	817.5
West Coast (Sumatra)	19,219	1,910,000	99.4
Tapanoeli (Sumatra)	15,000	1,042,000	69.1
East Coast (Sumatra)	36,500	1,693,000	46.4
Benkoelan (Sumatra)	10,100	323,000	31.9
Lampongs (Sumatra)	11,100	361,000	32.5
Palembang (Sumatra)	33,300	1,098,000	33.0
Djambi (Sumatra)	17,400	245,000	14.1
Atjeh (Sumatra)	21,300	1,003,000	46.9
Riouw-Lingga Archipelago	12,200	298,000	24.4
Bangka	4,610	205,000	44.5
Billiton	1,900	73,000	39.3
Borneo, West District	56,600	803,000	14.2
Borneo, East and South Districts	151,600	1,020,000	9.0
Menado (Celebes)	34,200	1,139,000	33.3
Dist. Celebes (Celebes)	38,800	3,093,000	79.7
Amboina (Molukkas and New Guinea)	75,800	401,000	5.3
Ternate (Molukkas and New Guinea)	115,800	493,000	4.3
Timor Archipelago	24,449	1,657,000	67.8
Bali and Lombok	4,510	2,052,000	453.7

The populations are predominately native Malayans (Javanese, etc.) with Europeans, Chinese, Hindus, Arabs, and others as small minorities. This is illustrated by the following table prepared from the 1930 census.

TABLE 2.—*Population groups in the Netherlands Indies in 1930*

	Europeans	Natives	Chinese	Others
Java and Madoera	192,000	40,891,000	582,000	53,000
All other islands	48,000	18,247,000	651,000	63,000
Total	240,000	59,138,000	1,233,000	116,000

The bulk of the population throughout the archipelago is concentrated in small native villages, *kompongs*. In Java, in spite of the tremendous population density, only 4.5 percent of the inhabitants live in cities of more than 50,000. In the other islands this percentage is still lower. The largest cities, Batavia (438,000), Semarang (218,000), Soerabaja (337,000), Bandoeng (163,000), and Djokjakarta (137,000) are in Java. The largest cities in Sumatra are Medan (75,000) and Padang (52,000). Makassar on Celebes has a population of 87,000. Borneo's largest cities are Pontianak (46,000) and Samarinda (11,000).

Up to the time of the invasion, the Netherlands Indies maintained a large and efficient Public Health Service, *Dienst der Volksgezondheid* (DVG), which functioned in cooperation with the Military Medical Service, *Militair-Geneeskundig Dienst* (MGD) as well as with missions and local administrative bodies. According to *Indisch Verslag* (1939), statistical organ of the Netherlands Indies Government, there were, in 1938, 472 physicians in the Public Health Service (including part-time and semi-official appointments and military physicians) and 765 cooperating with the Public Health Service in private practice. These were distributed according to table 3. These data include native as well as European physicians

TABLE 3.—*Physicians in the Netherlands Indies in 1938*

	Government physicians	Physicians in private practice
Java and Madoera	240	635
Sumatra	102	101
Borneo	34	11
Menado (Celebes)	20	5
Dist. Celebes (Celebes)	21	7
Molukkas and New Guinea	31	5
Timor, etc	13	1
Bali and Lombok	11	0
Total	472	765

In addition there were about 1,500 trained nurses, and 1,500 trained assistants of various types (malaria assistants, vaccinators, plague assistants, technicians, midwives, pharmacists, etc.), with a proportionate geographic distribution. There were 142 dentists.

There were at the time of the invasion two medical schools with eight-year courses and a dental school.

According to *Indisch Verslag* (1939) there were 625 hospitals, government, private with government subsidy, and private, in operation in 1938. The geographical distribution of these is shown in table 4.

TABLE 4.—*Hospitals in the Netherlands Indies in 1938*

	Number	Number of beds
Java and Madoera	228	29,271
Sumatra	183	22,143
Borneo	57	2,648
Menado (Celebes)	32	1,304
Dist. Celebes (Celebes)	40	2,007
Molukkas and New Guinea	43	1,738
Timor, etc	24	757
Bali and Lombok	18	921
Total	625	60,789

Throughout 1937 and 1938 these hospitals were filled within 98 percent of capacity.

In spite of the efforts of the Public Health Service, health and sanitation among the natives is grossly unsatisfactory. De Langen and Lichtenstein (1936) refer to "the terrible hygienic condition in the native villages" and further "* * * that the truly terrible hygienic conditions in the native quarters of the towns and native villages are a danger not only to the natives themselves but to the Europeans. * * * The natives are averse to cleanliness and fresh air."

Because of the concentration of the general population as well as of medical personnel and facilities on Java and Madoera, an overwhelming majority of the available medical information concerns these islands. Information from the outer "provinces" (entire Netherlands Indies except Java and Madoera) consists largely of fragmentary reports from physicians, surveys, and special research projects. Information from the interior of Borneo and New Guinea and from the Molukkas and some of the Lesser Soenda Islands is particularly meager. It is necessary to bear this in mind in considering medical and health problems in the Netherlands Indies. In many instances misleading or even incorrect conclusions could be reached by assuming conditions elsewhere in the archipelago to be the same as those in Java.

Chapter II

MALARIA

Malaria is unquestionably the most important disease in the Netherlands Indies. Although it is the cause of more deaths than any other single disease it has its greatest reflection in the general health of the population rather than as a primary cause of death. Its incidence is greatest among the natives but it is, nevertheless, a constant hazard to Europeans. Because of its prevalence and because most cases do not come to medical attention, reliable statistics on morbidity are not available. The data in table 5 are from the compilations of *Indisch Verslag* II (1935–1940).

TABLE 5.—*Hospitalized cases of malaria*

Year	Number of hospitals	Total number of admissions	Malaria admissions	Percent malaria admissions	Case fatality, percent	Percent deaths due to malaria
1934	221	207,325	15,510	7.5	3.1	—
1935	185	201,597	15,898	7.8	3.6	4.4
1936	190	223,469	16,942	7.6	3.7	4.6
1937	176	239,163	22,771	9.5	3.6	5.7
1938	167	238,960	23,177	9.7	4.4	6.7
1939	176	255,552	23,933	9.3	4.3	6.2

Most of the hospitals from which data in table 5 were obtained are in Java. It must be re-emphasized that only a minute portion of the malaria cases are hospitalized. Perhaps the importance of malaria is indicated more clearly by the calculations of Overbeek and Stoker (1938). These authors state that the crude mortality rate in rural Java is about 20:1000. In areas of chronic endemic ma-

laria the rate is 25–50:1000 per year and in regions with epidemic malaria the crude mortality may become as high as 400:1000 per year. Spleen indices in areas of chronic endemic malaria usually vary from 80 to 90 percent. According to the statistics of the annual report of the Medical Laboratory (*Jaarverslag van het Geneeskundig Laboratorium over 1935*) the malaria mortality rate in the Tjilatjap (Java) area, where an epidemic prevailed in 1935, was about 50:1000 per year. This represents a typical epidemic mortality rate.

The importance of malaria is further emphasized by the fact that the Netherlands Indies Public Health Service has maintained a separate malaria bureau with laboratories at Soerabaja and Batavia. The function of this organization is confined exclusively to the indentification of mosquito larvae and imagoes, examination of blood smears, determination of natural infection of vectors, etc. In 1937 more than 365,000 analyses and determinations were performed in these laboratories. This bureau has also conducted schools for malaria assistants (malaria mantris). These assistants are carefully trained in the collection and identification of anopheline mosquitoes, adults and larvae, as well as in the preparation and examination of blood smears and other useful technics. In 1939 there were nearly 200 of these assistants engaged in malaria control work in various parts of the archipelago.

Although infections by *Plasmodium vivax*, *P. falciparum*, and *P. malariae* occur, the majority of the cases are either tertian or subtertian. As in many other areas the distribution of *P. malariae* is very sporadic. It is said to be common in Bali, at Poerwaradi (East Java), Belawang, the port city of Medan (Sumatra), and in some of the villages around Toba Lake in Sumatra. In the Netherlands Indies Army, 0.4 gm. quinine per day is the standard suppressive measure. Quinine tablets have

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been issued to the natives by the Public Health Service and by plantations for many years. In recent years the therapeutic use of atabrin has become more and more popular among Dutch and native physicians.

Malaria Vectors

More than 60 species and subspecies of the genus *Anopheles* are known to occur in the Netherlands Indies. Of these about a dozen are recognized as vectors of varying degrees of importance. The vectors are sharply divided geographically between the Asiatic and Australian faunae. Vectors belonging to the Asiatic fauna (Indo-Malaysian) are *Anopheles sundaicus*, *A. aconitus*, *A. minimus*, *A. maculatus*, *A. kochi*, *A. hyrcanus* "group", *A. leucosphyrus*, and *A. umbrosus*. Australian vectors are *Anopheles bancroftii*, *A. punctulatus punctulatus*, and *A. punctulatus moluccensis*. The degree to which the Australian and Asiatic species overlap on the Molukkas, eastern Lesser Soendas, and other islands in this region is not well known at the present time. It is important to bear in mind the possibility of the spread of some species beyond their present ranges due to war conditions and rapid wartime transportation.

The principal sources of information on anophelines for this area are the monographs of Swellengrebel and Rodenwaldt (1932), Christophers (1933), and Weyer (1939). Important information also comes from the papers of Overbeek, Stoker, Rodenwaldt, Brug, de Rook, Walch, Soesilo, Schüffner, Mangkoewenoto, and others. In general the Dutch adhere to the nomenclature of Swellengrebel and Rodenwaldt (1932) which differs considerably from that in general use in English-speaking countries. The names used here are those of the accepted American nomenclature which adheres closely to Christophers' (1933). However, the Dutch synonyms are included

parenthetically to avoid confusion in consulting Dutch literature and in any collaboration with Dutch entomologists and malariologists.

In general it can be said that there is good information on the distribution of mosquitoes in Sumatra and adjacent islands, Java and adjacent islands, and the western Lesser Soenda Islands. Hundreds of collections have been made on these islands. Information from Celebes and the eastern Lesser Soendas is somewhat fragmentary as is that of the Molukkas. Reliable information from Borneo, particularly the interior, and New Guinea is extremely meager. In reference to New Guinea and the Molukkas, however, it can be assumed that the distribution of *A. punctulatus punctulatus* and *A. punctulatus moluccensis* as given in this compilation is essentially correct. Nevertheless it is necessary to bear in mind the variability in the knowledge of mosquito distribution in the various parts of the archipelago as outlined in this paragraph.

1. **Anopheles sundaicus (=ludlowi** var. **sundaicus).** This is the most important vector in the western part of the archipelago. There are two morphologically indistinguishable forms with different breeding habits. The *fresh-water form* has a limited distribution in the mountains of Sumatra whereas the *brackish-water form* occurs quite generally in coastal regions throughout the western part of the archipelago.

The brackish-water form breeds primarily in barrier lagoons near the mouths of streams, salt-water fish ponds, and other bodies of stagnating brackish water. The optimum salt concentration according to Weyer (1939) and Overbeek and Stoker (1938) is 12 to 18 gm. NaCl per liter. The upward limit appears to be about 40 gm. NaCl per liter. The breeding optimum according to Weyer (1939) is a mixture of about 1 part of sea water to 20 parts of fresh water. The larvae thrive only in water exposed to sunlight. According to some authors this

accounts for the fact that this species is not found on coasts with virgin mangrove forests. According to others its absence in these areas is due simply to the absence of accumulations of salt water among the mangroves. The larvae are further dependent upon the presence of filamentous green algae such as *Enteromorpha*, *Chaetomorpha*, *Spirogyra*, *Oscillatoria*, *Oedogonium*, *Lyngbya*, etc., as well as bottom aquatic plants. In general, ponds, lagoons, etc., which do not have filamentous algae do not have *sundaicus* larvae. However the water can be stagnant or turbid without affecting the occurrence of the larvae. The larvae of *A. subpictus* are frequently found with *sundaicus* larvae although the *subpictus* larvae can tolerate a higher salt concentration and the absence of the vegetation which is necessary for *sundaicus*. The *sundaicus* larvae, according to Overbeek and Stoker (1938), are never found in flowing water or in tidal water. Swellengrebel and Rodenwaldt (1932) are in agreement with this and suggest that it is the tidal influence which accounts for the absence of *sundaicus* in mangrove forests. In regions where the lagoons are periodically connected with the ocean the occurrence of larvae is in harmony with this periodicity, i. e., lacking during periods of connection.

Swellengrebel and Rodenwaldt (1932) cite unpublished data of de Nooy and Soesilo in speaking of the occurrence of the brackish-water *sundaicus* in fresh water in the hill country around Semarang, Java, in stagnating backwaters of rivers in East Java, and in fresh-water fish ponds in Bali. This agrees with some observations made in British India and is not to be confused with the fresh-water *sundaicus* of Sumatra.

The fresh-water *sundaicus* breeds almost exclusively in the fresh-water fish ponds in the long valleys of the Barisan Mountains in Sumatra. It has been reported from Greater and Lesser Mandailing (Rau, Panti, Padang

Sidempoean) at altitudes of 1,500 to 3,200 feet. The larvae also occur occasionally in the rice fields which are allowed to lie flooded after the harvest.

In these regions about 50 percent of the fresh-water fish ponds do not have *sundaicus* larvae. An explanation of this anomalous distribution does not exist. The presence of aquatic vegetation and particularly rooted aquatic plants seems to be an essential requirement for the fresh-water *sundaicus* larvae.

The adult *sundaicus* is a persistent house mosquito. On the south coast of Java about 60 percent of all mosquitoes found in houses are *A. sundaicus* and *A. aconitus*. Walch (1932) found that 86 percent to 96 percent of all *sundaicus* adults captured in houses contained human blood. In general the coastal *sundaicus* is numerous in June, July, and August with the numbers decreasing between September and November depending upon the season. This is correlated with the beginning of the dry season and the consequent increase in salinity in the ponds and lagoons. The adults are capable of flights of 1 to 3 kilometers (0.6 to 2.0 miles).

The rate of natural infection in adult mosquitoes varies considerably depending among other factors on the amount of human malaria present in the particular area. During severe epidemics natural infection of the mosquitoes may be as high as 20 percent or even 30 percent whereas normally it fluctuates from 1.0 to 10 percent in endemic areas and during light and moderate epidemics. Kuipers and Stoker (1934) found 46 percent in an epidemic on the north coast of Java. The potential (experimental) index of infection, i. e., percent infected under optimum experimental conditions, is high. Swellengrebel and Rodenwaldt (1932) state that it is 100 percent with *Plasmodium falciparum*, 80 percent for *P. vivax*, and 20 to 25 percent for *P. malariae*. It is a rule of thumb that wherever *sundaicus* occurs so also does malaria.

Because of differences in nomenclature there is some difficulty in ascertaining the exact status of the northern limits of the range of *Anopheles sundaicus*. According to Swellengrebel and Rodenwaldt (1932) it occurs on the coasts of Java, Sumatra, and adjacent islands (except in mangrove areas) as well as on the coasts of all of the Lesser Soenda Islands. In recent years it has extended its range northward to southern Celebes and adjacent islands where in replacing *subpictus* it has caused severe epidemics. Overbeek (1940) reports a severe epidemic in Celebes with *sundaicus* 54 perent infected. The distribution in Borneo is not well known. It is said not to occur wherever there are mangrove forests. Nevertheless, because of the present lack of adequate information, its possible occurrence on this island must be constantly borne in mind. Walch and Soesilo (1929) described a form from the east coast of Borneo around Balikpapan which they state is intermediate between *A. sundaicus* and *A. ludlowi* of the Philippine Islands. *A. ludlowi* is known to occur on Ceram in the Molukkas.

It is necessary to emphasize again that, although there are numerous vectors in the western part of the archipelago, *Anopheles sundaicus* is without a doubt the most dangerous (fig. 1, Appendix C).

2. **Anopheles subpictus.**—The breeding habits of this vector are somewhat similar to those of *A. sundaicus* although it is much more ubiquitous. Larvae can be found in habitats varying from rice fields to brackish-water bodies with salt concentrations as high as 85 gm. NaCl per liter. Because of this toleration for a wide variety of habitats the larvae of this species are numerous.

The adults are also extremely numerous. Next to *sundaicus* it is the most abundant species captured in houses. However, it seems to prefer to bite livestock. The status of *subpictus* as a vector is a matter of contro-

versy. According to Soesilo (1928) the index of experimental infection is 40 percent. Natural infection appears to vary from 0.2 to 1.2 percent (mean, about 0.3 percent). Walch (1932) found only 15 percent of the females with human blood. Christophers (1933) is inclined to believe that it is not a vector. However, his conclusions are based largely on experience in British India. In the Netherlands Indies it is difficult to obtain good evidence because *subpictus* usually occurs simultaneously with other vectors. Dutch malariologists are in agreement that because of its large numbers it can at times be a dangerous vector in spite of its low natural infection. In southern Celebes in areas where it has not been replaced by *A. sundaicus* it is regarded as an important vector.

Anopheles subpictus is known to occur generally on Java, Sumatra, Riouw, etc., the Lesser Soendas, Molukkas, Celebes, New Guinea, and adjacent islands. Although there are only two records from the east coast of Borneo it may be well to assume that its distribution on this island is much more extensive (fig. 2, Appendix C).

3. **Anopheles aconitus.**—This species occurs in the plains as well as in the mountains. Larvae are found in such places as fallow flooded rice fields (after the harvest), fresh-water fish ponds, poorly maintained irrigation ditches, and to a lesser extent in flowing water such as in small brooks. Rice fields and fresh-water fish ponds are the most common breeding habitats. The larvae are seldom or never found in brackish, turbid, or dirty water.

Although this species is a house mosquito and the females bite humans there seems to be a preference for livestock. In regions with few livestock, 60 percent of the mosquitoes were found by Walch (1932) to contain human blood. The flight of adults seems to be limited to less than 600 yards from the breeding places; *aconitus* is a nocturnal flier. There is a definite periodicity in the

aconitus population. The *aconitus* season frequently coincides with the rice harvest if water is allowed to stand in the fields where the rice straw is not removed. After the harvest the "*aconitus* season" seems to decline.

There is some disagreement concerning the role of this species as a vector. Nevertheless there can be no doubt that at times in the Netherlands Indies it is a vector of importance and the cause of severe epidemics. Experimental infections of 46 percent with *P. falciparum* are reported by Swellengrebel and Rodenwaldt (1932) who give its natural infection as 0 to 7.3 percent (mean, 1.7 percent). Overbeek and Stoker (1938) reported an epidemic natural infection of 17.8 percent. Although *aconitus* is abundant in many areas in Sumatra it has usually been found uninfected except on the east coast of Tapanoeli and in Djihara in South Sumatra. The Dutch are inclined to regard this species as a potentially dangerous vector capable of producing severe epidemics.

Because of the difficulty in distinguishing this species from *A. minimus* the exact distribution is not known. Perhaps it is best to accept the statement of Weyer (1939) who says it occurs everywhere in the Netherlands Indies between the altitudes of 1,200 and 2,500 feet, and some places up to 3,000 feet. It may be best to assume that this is also true for Borneo although there are no records to support this assumption at present (fig. 3, Appendix C).

4. **Anopheles minimus.**—This species is very similar to *Anopheles aconitus*. Actually certain differentiation can be made only by examination of the larvae. (The *aconitus* larvae have branched or frayed clypeal hairs; the clypeal hairs of *minimus* are not branched or frayed. The *aconitus* imagoes usually have a fringe-spot at vein 6 whereas the *minimus* imagoes usually do not.) The exact status of the Netherlands Indies *minimus* is uncertain. Swellengrebel and Rodenwaldt (1932) merely refer to it

as *A. minimus*. Overbeek and Stoker (1938) regard it as *A. minimus flavirostris* (=*minimus* var. *flavirostris*), the Philippine form. Swellengrebel and Rodenwaldt (1932) state that *Anopheles varuna* (=*minimus* var. *varuna*) occurs in Sumatra although Overbeek and Stoker (1938), Weyer (1939), and Christophers (1933) do not agree. For practical purposes it appears most advisable to speak merely of *Anopheles minimus* until the taxonomic relationships are more apparent. According to Christophers (1933) *flavirostris* is indistinguishable from *minimus*. Actually, if necessary in malaria control, *aconitus* and the *minimus* forms can be dealt with as a single problem.

Anopheles minimus breeds primarily in flowing water although there is a certain degree of adaptability in its breeding habits. Larvae are found in brooks, creeks, bays in rivers, and springs—particularly where there is abundant aquatic vegetation. They also occur in irrigation canals, ponds, and even in rice fields. The water in which they occur is usually clear, clean, cool, standing or flowing, and slightly shaded or exposed to sunlight. Larvae are never found in turbid or cloudy water, nor in water with surface algae, with iron oxide, or abundant bacteria, nor in brackish water. This species is restricted, to a certain extent, to the mountainous country. In irrigated country *minimus* may persist in great numbers after the rice fields have been drained and *aconitus* has all but disappeared. This is due to the fact that the water does not disappear as quickly from the irrigation ditches.

A. minimus is a house mosquito with a distinct preference for human blood. Because of the confusion of this species with *A. aconitus* there is not much reliable information on its role as a malaria vector in the Netherlands Indies. It has been found at Minahassa (Celebes) with 3 percent natural infection. In India, however, it is regarded as an extremely dangerous vector. Overbeek and

Stoker (1938) state that it was found infected in Celebes, Tjipandani, and on Poeloe Laoet near Borneo. Because of this confusion between *A. minimus* and *A. aconitus* both should be considered provisionally as vectors of importance.

The distribution of *minimus* is not clear because of confusion in differentiation from *aconitus*. However it can be said with a considerable degree of assurance that *minimus* occurs on all the islands west of Wallace's line although virtually nothing is known of its distribution on Borneo (fig. 3, Appendix C).

5. **Anopheles varuna** (=**minimus** var. **varuna**).—This species is reported by Swellengrebel and Rodenwaldt (1932) from Sumatra although Weyer (1939), Overbeek and Stoker (1938), and Christophers (1933) do not agree. Weyer (1939) and Christophers (1933) are in agreement that its status as a vector is doubtful although obscured because of its similarity to *A. minimus*. If it does occur in the Netherlands Indies it certainly is not numerous and therefore not to be recognized as a vector of any consequence (fig. 3, Appendix C).

6. **Anopheles maculatus.**—This is a species of the hill and mountain country where it is found up to altitudes of 3,200 feet. Normally it breeds in rapidly flowing mountain brooks and streams in blind pockets, behind stones, or wherever whirlpools occur. However larvae are found sometimes in ponds, springs, open wells, marshes where there is fresh water, and even in rice fields and water tanks. The presence of macroscopic aquatic vegetation is apparently unnecessary in the breeding habitats. *Sunlight and clear water, rich in oxygen, appear to be the principal requirements of the larvae.* In Java this species breeds rather frequently in rice fields along with *A. aconitus*. This species rarely occurs in virgin forests unless the natural cover on the banks of the streams is removed.

Removal of this cover exposes the water to sunlight making it ideal for *maculatus* larvae.

The *maculatus* imagoes are nocturnal fliers and usually bite between 9:00 p. m. and 2:00 a. m. During this time they will enter dwellings to bite humans. However they do not remain in the dwellings and are rarely captured there. Infected females can be taken along stream banks during the day. There is considerable disagreement among the various investigators as to whether this species is primarily zoophilic or anthropophilic. In the Netherlands Indies however it appears to be zoophilic although it will attack man vigorously in regions where there is little livestock.

Swellengrebel and Rodenwaldt (1933) report an artificial infection of 47 percent although Weyer (1939) cites much lower indices. Natural infection is about 2 percent in the Netherlands Indies although in Malaya parasite indices as high as 11 percent have been recorded.

Most *maculatus* malaria is "man-made" by the removal of the jungle shade from the banks of small streams. This situation is particularly true in the tea plantations in Java. It is also regarded as a vector in the Riouw Archipelago, Banka (Bangka) Islands, Nias Island, and Sumatra. It is troublesome on many of the rubber plantations. This species has been reported from Sumatra and many of its adjacent islands, Java, many of the Lesser Soendas, Celebes, Buton (Boetoeng), and East Borneo. Because of its distribution in mountainous areas its exact range is certainly not well known at the present time (fig. 4, Appendix C).

7. **Anopheles hyrcanus.**—Swellengrebel and Rodenwaldt (1932) include six forms in this species. They are *A. separatus* (=*hyrcanus separatus*), *A. hunteri* (=*hyrcanus hunteri*), *A. hyrcanus nigerrimus* (=*hyrcanus typicus* var. *niggerima*), *A. hyrcanus pseudopictus* (=*hyrcanus*

typicus var. *pseudopicta*), *A. hyrcanus sinensis* (=*hyrcanus typicus* var. *sinensis*), and a form which these authors call *A. hyrcanus peditaeniatus*. Its exact status is difficult to ascertain from the literature. Gater (1934) regards Walch's identification as incorrect and believes the form to be *A. montanus* (=*albotaeniatus* var. *montanus* of Swellengrebel and Rodenwaldt). The *pseudopictus* of Swellengrebel and Rodenwaldt is regarded by Weyer (1939) and Gater (1934) as synonymous with *hyrcanus nigerrimus*. The picture, however, is further confused by the reference of Dutch authors to *hyrcanus* X from Celebes, Java, and Borneo supposedly a distinct form.

Venhuis (1939) has studied the *hyrcanus* group extensively. He believes that most of the *hyrcanus* of Java and Celebes, at least, belong to a hitherto undescribed form which he refers to as *hyrcanus* X. It is described as similar to *A. hyrcanus williamsi* of Malaya. Venhuis (1939) gives the following key to the separation of *hyrcanus* X from *sinensis* and *nigerrimus:*

KEY TO SEPARATION OF *hyrcanus* X FROM *sinensis* AND *nigerrimus*

Larva.

1. Sutural hairs with 2–12 branches, antenna slender, and evenly yellow (like in *A. barbirostris*) -------- *A. hyrcanus sinensis* or *nigerrimus*
2. Sutural hairs 13–23 branches; antenna swollen, clear and transparent or in basal half dark brown -------------------- *A. hyrcanus* X

Pupa.

1. a. Outermost plumose hair on posterior margin of segment III 8–38 branches -- 2
   b. Outermost plumose hair on posterior margin of segment III 48–80 branches ---------------------------------- *A. hyrcanus* X
2. a. Spine on segment VIII 8–30 long branches - *A. hyrcanus sinensis*
   b. Spine on segment VIII 1–7 short sidehairs - *A. hyrcanus nigerrimus*

Adult.

1. a. Dark spot on stem of vein 5 short, while tarsal bands on hind leg narrow, tarsal segment 4 basally dark ---- *A. hyrcanus sinensis*
   b. Dark spot on stem of vein 5 long -------------------------- 2

KEY TO SEPARATION OF *hyrcanus* X FROM *sinensis* AND *nigerrimus*—Continued

Adult—Continued.

2\. a. Dark spot on middle of vein 6 longer than apical one -- *A. hyrcanus nigerrimus*

b. Dark spot on middle of vein 6 shorter than apical one -- *A. hyrcanus* X

The importance of the differentiation of these groups lies in the fact that Venhuis is quite certain that *hyrcanus* X is the important vector and that *nigerrimus* and *sinensis* are uncommon. According to him previous identifications (such as those recorded on the maps in Appendix C) are in error and that these are probably *hyrcanus* X.

All forms in the preceding paragraphs are dealt with collectively in this paper as the "*hyrcanus* group." This usage is employed not alone because of the confusion in the taxonomic literature but also because of their similar breeding habits and further because most of the Dutch records do not distinguish the various members of this group. In malaria control it has been common practice in the Netherlands Indies to deal with this group as an entity.

Mosquitoes of the *hyrcanus* group are typically swamp and rice field breeders of open country. The larvae are rarely found in stagnating water and there is but a single record of brackish-water breeding. Larvae are found in large numbers only in the presence of an abundance of aquatic vegetation. Breeding habitats are frequently created in clearing operations in low land.

According to Swellengrebel and Rodenwaldt (1932) the adults have a strong preference for the blood of livestock and hence there is less danger from this group in areas where livestock is abundant. However Overbeek and Stoker (1938) describe it as a house mosquito with a preference for human blood; Walch (1930) speaks of areas in

which 80 to 90 percent of the females contained human blood. There is considerable disagreement as to the importance this group has in the transmission of malaria. Swellengrebel and Rodenwaldt (1932) cite natural infections of 0 to 11 percent (mean, 1.7 percent). The group is regarded by some as an important vector in Java and Sumatra although Soesilo (1935) regards it as unimportant in Java. The heterogeneity of the *hyrcanus* group may well account for the disagreement concerning its role in malaria transmission. There are records of *hyrcanus* mosquitoes from most of the islands west of Wallace's line. However, it is probably not numerous on the Lesser Soendas (fig. 5, Appendix C).

8. **Anopheles kochi.**—In the Netherlands Indies the larvae of this species are found breeding in places with turbid water, in puddles on roads, buffalo hoof-prints, puddles with decaying leaves, etc. Larvae have also been reported from mountain brooks, springs, rice fields, and fresh-water ponds. The females prefer the blood of livestock to that of man. Experimentally, according to Swellengrebel and Rodenwaldt (1932) it can be infected to 50 percent with *P. falciparum* and 7 percent with *P. vivax*. In the Netherlands Indies natural infection varies from 0 to 5 percent (mean 0.85 percent). In general *kochi* is an unimportant vector. During the rainy season when its numbers increase tremendously it may be the cause of small epidemics. It is distributed quite generally over the entire archipelago west of Wallace's line (fig. 6, Appendix C).

9. **Anopheles leucosphyrus.**—*A. leucosphyrus leucosphyrus* (=*leucosphyrus*) and *A. leucosphyrus hackeri* (=*leucosphyrus* var. *hackeri*) are recognized. However, because these forms can be distinguished only by examination of the adult females the species will be treated as a whole. Larvae are found in shaded water. The amount

of vegetation and the temperature of the water does not seem to be of consequence. Springs, puddles, and buffalo hoof-prints are typical habitats of *leucosphyrus* larvae. Natural infection is about 1 percent. In general it is not to be regarded as an important vector in the Netherlands Indies. However Goelarso (1934) has shown it to be an important vector in East Borneo. It may be of importance elsewhere in Borneo. Recent investigations by Venhuis (1942) indicate that its importance as a vector in Java may be greater than previously assumed. There are records of this species from Riouw Archipelago, Sumatra, Java, Borneo, Celebes, and Buton (Boetoeng) Island (fig. 7, Appendix C).

10. **Anopheles umbrosus.**—In the Netherlands Indies the larvae of this species are found in clear water with or without aquatic vegetation in such places as springs, old water tanks, puddles, ponds, and brooks. In brackish water they are found in grassy puddles among nepah palms, coconut palms, or mangrove trees. The brackish-water form may be a separate subspecies. Usually *umbrosus* breeds in shaded habitats although the larvae are frequently found in water exposed to sunlight. Adults often occur in dwellings. Natural infection in the Netherlands Indies appears to be about 2 percent. Walch (1932) demonstrated that this species is strongly anthropophilic. Goelarso (1934) reported *umbrosus* to be a dangerous vector on Banka (Bangka) Island. It may also be a vector of importance on Borneo. Elsewhere in the Netherlands Indies it does not appear to be as important.

There are records of *umbrosus* from Borneo, Celebes, Java, Sumatra and adjacent islands, and Boeroe Island (fig. 8, Appendix C).

11. **Anopheles punctulatus moluccensis (= punctulatus typicus** var. **moluccensis).**—The two subspecies of *Anopheles punctulatus*, *punctulatus* and

moluccensis, are the important malaria vectors in the Australian part of the Netherlands Indies, i. e., New Guinea, Molukkas, and adjacent islands. The important characteristic of all breeding places of *moluccensis* is exposure to open sunlight. Actually this seems to be the only common factor in the habitats of the larvae for they are to be found almost without exception in water exposed to sunlight. Consequently much of the *moluccensis* malaria is "man-made" due to clearing operations and the resulting exposure of pools, puddles, etc., to sunlight. Repeatedly preliminary surveys of jungle areas have shown them to be of low endemicity before the beginning of mining or plantation developments only to have severe epidemics. break out following the clearing operations. De Rook (1938) describes epidemics at Tanah Merah caused by this sudden appearance of *moluccensis* following the establishment of a gold-mining camp. The *moluccensis* larvae are found in all bodies of water exposed to sunlight including brooks, drainage ditches, mud puddles, ponds, in brackish-water puddles in coastal regions, along the grassy banks of the Digoel River (perhaps in other rivers), buffalo hoof-prints, bilge water in boats, springs, etc. The presence and type of vegetation appear to be of little importance. When larvae occur in the larger streams such as the Digoel River they are to be found, according to de Rook (1938), near the banks among aquatic plants as well as in seepage pools and cut-off pools with no direct connection with the stream.

According to Swellengrebel and Rodenwaldt (1932) *moluccensis* is second in importance as a house mosquito in New Guinea only to *A. bancroftii*. However Overbeek and Stoker (1938) regard *moluccensis* as the most numerous house mosquito. Walch (1930) has shown that it feeds exclusively on human blood. Swellengrebel and Rodenwaldt (1932) describe *moluccensis* as "decidedly" a noc-

turnal flier. Natural infection in *moluccensis* has been reported as high as 13 percent although the mean is perhaps about 7 percent.

All Dutch malariologists agree that *A. punctulatus moluccensis* is a vector of prime importance in New Guinea, the Molukkas, and adjacent islands. However, Swellengrebel and Rodenwaldt describe an anomalous situation in the Molukkas where both *punctulatus punctulatus* and *punctulatus moluccensis* occur. Here in spite of the presence of these vectors malaria is not correspondingly prevalent. Nevertheless, the importance of *moluccensis* as a vector cannot be overemphasized nor can the ease of creating "man-made" malaria by providing breeding habitats for this subspecies be considered too seriously.

A. punctulatus moluccensis occurs throughout Dutch New Guinea both on the coast and in the interior up to altitudes of 3,500 feet wherever there are suitable breeding habitats. Because of its occurrence on the Molukkas, Ceram, Soela Islands, Aroe, Japen Island, Batjan Island, Misool, Saparoea (South of Ceram), Boeroe, etc., it is to be assumed that this form occurs on all of the islands east of Wallace's line. There is a single record west of Wallace's line from the Banggai Islands off the east coast of Celebes (fig. 9, Appendix C).

12. **Anopheles punctulatus punctulatus.** — In many ways this subspecies is similar to *moluccensis* so that their control is reduced to a single problem. The larvae of *punctulatus* like those of *moluccensis* are to be found in all types of accumulations of water exposed to sunlight. Water-filled hoof-prints, gutters, ditches, water tanks, water barrels, bilge water in boats, tin cans, coconut shells, etc., are mentioned specifically. The type of water, whether clear or turbid, and the presence or absence of aquatic vegetation appear not to be factors. According to

de Rook (1938) it differs from *moluccensis* in that it does not breed in flowing water; it is possible that statements concerning the occurrence of *punctulatus* larvae breeding in brooks in the Molukkas are the result of confusion with *moluccensis* larvae. The larvae are also found in water accumulations in stands of Sago palm. Because this subspecies requires sunlight in its breeding habitat it is often, along with *moluccensis*, the vector in "man-made" malaria.

The imago is nocturnal. Very few appear before nine o'clock in the evening. The female hums very little and its bite is quite unnoticeable. Consequently personnel can be attacked when unprotected by netting. This danger is increased by the fact that *punctulatus* adults frequently occur where there are very few mosquitoes of other species present and therefore when adequate protection is not being practiced. This is sufficiently obvious to have given rise in New Guinea to a proverb which in translation is: "Where there are few mosquitoes there is much malaria."

In Tanah Merah on the upper Digoel River in New Guinea this subspecies occurs with *moluccensis* but it is not as numerous. Here it is definitely seasonal, appearing in small numbers in March and becoming numerous in June. It is not known whether or not this periodicity exists elsewhere.

There can be no question of the importance of *punctulatus punctulatus* as a vector even though the observed natural infection 1.5 to 5 percent is lower than that of *moluccensis*. According to Walch (1930) it is exclusively anthropophilic. However, there are places, according to Swellengrebel and Rodenwaldt (1932) where this subspecies is very numerous without a proportionate amount of malaria in the population.

The geographical distribution of *punctulatus punctulatus* is practically coincident with that of *moluccensis* (fig. 9, Appendix C).

13. Anopheles bancroftii (=barbirostris bancrofti).—Elsbach (1938) first discovered the breeding habitat of this species in New Guinea. The larvae were found in partially shaded lakes with macroscopic aquatic plants and clear water. Occasionally the larvae are found in back waters of rivers but this is not a typical habitat.

The exact status of *bancroftii* as a malaria vector is a matter of controversy. This is due to the fact that *bancroftii* rarely occurs apart from *punctulatus punctulatus* or *punctulatus moluccensis*, making its role difficult to ascertain. Also there has been taxonomic confusion with *A. barbirostris* (*=barbirostris typicus*) and *A. pseudobarbirostris* (*=barbirostris bancrofti* var. *pseudobarbirostris*).

Brug (1925) regarded *bancroftii* as an important vector in New Guinea. However, de Rook (1938) regards it as secondary in importance. He reports a natural infection of 4.3 percent at Tanah Merah. According to Walch (1930) *bancroftii* is anthropophilic. It is a nocturnal flier.

The exact distribution of this species is unknown. Larvae have been found in the interior and on the south coast of New Guinea. De Rook (1938) reports that it has been found at Kloofbivak on the Lorentz River, in the Merauke region, Etna Bay region, and at Prauwenbivak. He states that it does not occur on the north coast of New Guinea. Nevertheless it appears safest to expect to encounter this species throughout New Guinea, the Molukkas, and adjacent islands (fig. 10, Appendix C).

Brug (1937) has reported *bancroftii* from Celebes, where, according to him, it is not anthropophilic. Later (1938) he described the Celebes form as a separate subspecies, *A. bancroftii barbiventris*. Since he records it only at Karwari and the adjacent area and since it is apparently not a vector it has not been included on the maps in this manual.

Doubtful vectors.—Swellengrebel and Rodenwaldt (1932) cite natural infections of 0 to 0.5 percent for *A. barbirostris* which occurs commonly throughout the archipelago (fig. 11, Appendix C). Because the indices are very low it is doubtful that this species is of more than occasional importance as a vector. Machsoes (1939) describes an epidemic at Tempe Lake in Celebes in which *barbirostris* was the vector. In Malaya *barbirostris* is a vector of some importance with natural infections of 1.0 to 7.5 percent. For this reason it must be considered as a potential vector in the Netherlands Indies.

A. pseudobarbirostris is regarded by some entomologists, such as Weyer (1939), as possibly synonymous with *A. bancroftii*. Swellengrebel and Rodenwaldt (1932) regard it as a subspecies of *bancroftii* whereas Christophers (1933) regards it as a good species in the Netherlands Indies on Celebes. Its status as a vector is uncertain.

A. punctulatus novaguinensis and *A. amictus* are possible vectors although evidence is completely lacking at the present time.

Weyer (1939) mentions *A. aitkenii* as a possible vector, especially on the Molukkas. *A. karwari* can be infected experimentally with considerable ease. However, there is no evidence that it has a role as a vector. *A. tessellatus*, *A. annularis*, and *A. vagus* have been found infected. *A. pallidus* is a vector in India but has been reported only from a single locality in Sumatra and is therefore not considered a vector in the Netherlands Indies.

SYNOPSIS OF MALARIA VECTORS

Vector	Geographic distribution in Netherlands Indies	Breeding habitat
A. sundaicus	Java and adjacent islands, Sumatra and adjacent islands, Lesser Soenda Islands, southern Celebes.	Salt-water lagoons, salt water fish ponds (in fresh-water fish ponds in mountains of Sumatra).
A. subpictus	Most islands west of Wallace's line.	Similar to *sundaicus* but more ubiquitous.
A. aconitus	Everywhere west of Wallace's line between altitudes of 1,200 and 2,500 feet.	Flooded fallowed rice fields, fresh-water fish ponds, ditches, etc.
A. minimus	All islands west of Wallace's line.	Primarily in flowing water with abundant aquatic vegetation.
A. maculatus	Mountain and hill country of islands west of Wallace's line.	Primarily in mountain streams; sometimes in rice fields. *Sunlight is necessary.*
A. hyrcanus group	Most of the islands west of Wallace's line.	Primarily in swamps and rice fields.
A. kochi	Generally distributed on islands west of Wallace's line.	Small collections of water such as hoof-prints, puddles, etc., also brooks and rice fields.
A. leucosphyrus	Known to occur in Riouw, Sumatra, Java, Borneo, Celebes, Boetoeng; doubtlessly on other islands.	Small bodies of water. *Shade is required.*
A. umbrosus	Known to occur on Borneo, Celebes, Java, Borneo, Sumatra and adjacent islands.	Usually in shade although sometimes in water exposed to sunlight. Ponds, puddles, tanks, etc. Brackish and fresh water.
A. punctulatus moluccensis.	New Guinea and other islands east of Wallace's line.	In all types of collections of water, fresh or brackish, standing or flowing. *Sunlight is required.*

IN THE NETHERLANDS INDIES

Habits of adults	Natural infection	Importance as a vector	Remarks
Anthropophilic. Persistent house mosquito.	High (1–10%).....	Most important vector in western Netherlands Indies.	May be periodic where there are dry and wet seasons.
More zoophilic than anthropophilic.	Low (usually less than 1%).	Occasionally of importance.	Adults are very abundant.
Probably more zoophilic than anthropophilic.	Moderate (mean, 1.7%).	A dangerous epidemic vector in the interior.	
An anthropophilic house mosquito.	Generally low.....	Uncertain..........	Known to be a vector in epidemics in Borneo and Celebes.
Enters houses temporarily and bites humans.	Generally about 2%.	An important vector on rubber and tea plantations.	Vector in "man-made" malaria caused by removing cover from mountain streams.
Anthropophilic to a considerable degree at least.	Moderate (mean, 1.7%).	Important in Java and Sumatra.	
Primarily zoophilic..	Low (mean, 0.85%)	Unimportant.......	
....	Low (mean, 1%)..	Unimportant except possibly in Borneo.	
Adults occur in dwellings—anthropophilic.	About 2%........	Important in Borneo and Banka.	
Exclusively anthropophilic.	High (mean, 7%)..	Very important in eastern part of archipelago.	

Vector	Geographic distribution in Netherlands Indies	Breeding habitat
A. punctulatus punctulatus.	Same as *moluccensis*----------	Same as *moluccensis* except that it is said not to breed in flowing water.
A. bancroftii-----	Probably the same as *moluccensis* although less common throughout its range.	In small shady clear-water lakes with aquatic vegetation.

THE NETHERLANDS INDIES—Continued

Habits of adults	Natural infection	Importance as a vector	Remarks
Exclusively anthropophilic. Has no "hum"; bite is painless.	Not as high (mean, 3.5%).	Very important in eastern part of archipelago.	Adults frequently occur where there are no other adult mosquitoes.
Anthropophilic	Probably lower than *A. p. punctulatus*.	Exact status not known. Must be regarded as a vector.	

Geomalariology of the Netherlands Indies

Malaria occurs on all of the inhabited islands from sea level to altitudes of 4,000 to 5,000 feet. The occasional vague references to "malaria-free" islands seem to be without exception unfounded. The notes on the geographical distribution of malaria are derived largely from Overbeek and Stoker (1938), Rodenwaldt (1939), Swellengrebel and Rodenwaldt (1932), Walch and Soesilo (1929, 1938), reports of the Malaria Bureau in *Mededeelingen van den Dienst der Volksgezondheid in Nederlandsch-Indië*, and miscellaneous papers in recent volumes of *Mededeelingen van den Dienst der Volksgezondheid in Nederlandsch-Indië* and *Geneeskundig Tijdschrift voor Nederlandsch-Indië.*

Endemic malaria is common in the Netherlands Indies. Where endemic malaria does not occur there are epidemics at varying intervals. The Dutch have employed modern and ingenious methods of control at tremendous financial expenditure for many years. In spite of this endemic malaria still exists in uncontrolled areas and epidemics appear sporadically even in those areas with rigid control. It is to be assumed that the control programs, many of them expensive and intricate in manipulation, have broken down following the Japanese invasion and occupation.

In spite of the universal occurrence of malaria in the entire archipelago information on its geographical aspects is of value, frequently a necessity, because of the relatively large number of vectors, with vastly different habits, requiring different types of control.

Information on the geographical distribution is contained in the discussions of the vectors and in more detail in Appendix C which contains maps and collecting records.

Two approaches to geomalariology appear to be useful: (1) The geographical situations which are conducive to malaria i. e., rice fields, fish ponds, etc., and the conditions and vectors involved; (2) the general island-by-island picture in so far as information is available. It is important to emphasize that the following notes on the geography of malaria (from both approaches) are fragmentary and incomplete. It should be re-emphasized that *malaria is widespread on all of the islands of the archipelago.* By use of the maps in Appendix C, the description of the vectors, as well as consultation of geologic and geographical information, malaria problems can be anticipated to a certain extent.

Malaria in Relation to Certain Geographical Features.

Brackish-water lagoons.—Lagoons are found on the southern coasts of Java and the Lesser Soenda Islands as far east as Roma due to the action of the surf caused by the prevailing southerly winds. Dilution of sea water in these lagoons by rains results in saline concentrations optimum for *subpictus* and *sundaicus* larvae. The former are adaptable to a much higher concentration of salt than the latter and also are able to live in water which is virtually free of aquatic vegetation. Fortunately *subpictus* because of its lower index of natural infection, is much less important as a vector than *sundaicus*. Particularly dangerous are those lagoons which are fed by streams because the salt concentration is almost certain to be within optimum range for *sundaicus* larvae. Similar lagoons with *sundaicus* larvae are found on the west coast of Sumatra as well as certain sectors on the coast of Celebes. There are brackish-water lagoons on the Molukkas which are breeding places of *punctulatus moluccensis* whose larvae can tolerate a considerable degree of salinity.

All areas with brackish-water lagoons must be regarded as areas of endemic malaria.

Mangrove forests and malaria.—Dutch malariologists, as well as Strickland (1936), seem to be in agreement that the low muddy coastal areas which are covered with primitive mangrove forests are generally free or partially free of malaria. This is associated with the lack of breeding places suitable for *sundaicus* larvae. Because of the nature of the tidal wash in the mangrove there are very few accumulations of water and those which do exist have salt concentrations too high for *sundaicus* larvae. However, *umbrosus* larvae may occur. The east coast of Sumatra and most of the Borneo coast are muddy and covered with mangrove and are therefore relatively free of malaria. There are a few such areas on the north coast of Java. Palembang, a city of more than 80,000 inhabitants in South Sumatra, Pontianak, and Bandjermasin in Borneo although located in swamps and near rivers are practically free of malaria because of the proximity of mangrove and favorable tidal fluctuations which keep the saline concentration of accumulations of water too high for anopheline larvae. On the other hand Batavia and Soerabaja which do not enjoy favorable tidal action and the proximity of mangrove forests are notorious centers of endemic malaria.

In general mangrove forests are disagreeable because of hordes of pestiferous culicines and other diptera, as well as dense underbrush, high humidity and temperatures. Any obstruction to the natural drainage of the mangrove forest such as caused by the construction of roads, footpaths, drainage ditches, or felling of trees allows the accumulation of brackish water and breeding by *sundaicus* or *subpictus* or both. The eastern part of Semarang in central Java and Tegal on the north coast of Java are examples of endemic malaria areas caused in this manner.

Any type of operation in mangrove areas can therefore result in "man-made" malaria unless proper precautions are taken.

Salt-water fish ponds.—Pisciculture is extensive in Java and Madoera. Many of the ponds have been constructed near the coast and contain brackish water. They provide excellent breeding places for *sundaicus* not only by obstructing the natural drainage but also because it is believed by the natives that the surface of the ponds must have floating filamentous green algae (*Enteromorpha*, *Chaetomorpha*, *Spirogyra*, etc.) in order to secure the best growth among the fish. It is among these algae that the *sundaicus* larvae are found. The principal fish cultured in the salt-water fish ponds is the bandeng (*Chanos chanos*). Probolinggo and Banjoewangi on the east coast of Java were centers of "fish-pond" malaria until the ponds were connected with the ocean. Occasionally rice fields near the coast become brackish, creating a problem similar to the salt-water fish pond with *sundaicus* as the vector.

Fresh-water fish ponds.—Special mention should be made of the chronic endemic malaria of the long valleys of the Barisan Mountains (Mandailing) in Sumatra. The vector is the fresh-water form of *sundaicus* whose larvae are found in fresh-water fish ponds and lakes. *A. aconitus* is also a vector of some importance in these regions. Rao (Rau), Panti, and Padoeng Sidempoeam are located in the region of "fresh-water *sundaicus*" malaria.

Fresh-water fish ponds are used for culturing carp (*Cyprinus*) and more frequently gorami (*Osphromenus olfax*). Here also the natives believe that a growth of green algae on the surface is essential for the growth of the fish. Many of the fish ponds are temporary i. e., ponds made by flooding rice fields after the harvest and without removing the straw. This results in an abundant growth of green algae and an excellent habitat for an-

opheline larvae. In addition to the fresh-water *sundaicus* which occurs only in the Barisan Mountains in Java other anophelines breed in fresh-water fish ponds.

A. aconitus sometimes occurs in fish ponds in Java and Sumatra, especially in those in rice fields. *A. hyrcanus* breeds in fresh-water fish ponds especially on the plateau in southern Sumatra.

Rice-field malaria.—Fortunately there are no vectors in the Netherlands Indies which breed extensively in the rice fields during the time at which the rice is growing. In general anopheline larvae do not appear in appreciable numbers until after the rice harvest and then only in flooded fields in which the straw has not been removed. It is common practice among the natives to leave the straw in the fields and to allow them to remain flooded after the harvest. The Dutch have eliminated much malaria by preventing this. The principal rice-field breeding vectors are *aconitus* and *hyrcanus*, the former being the most dangerous. Occasionally *maculatus*, *kochi*, and *minimus* larvae are also found in rice fields. *A. aconitus* and *maculatus* may be found breeding in rice fields at altitudes as high as 3,000 to 4,000 feet.

Malaria due to clearing operations.—The removal of the virgin forest and underbrush frequently results in the exposure of water to sunlight thereby creating breeding habitats for the anophelines whose larvae are "sun-loving." In the western part of the archipelago the "sun-loving" species is *maculatus* which breeds in mountain streams and occasionally in springs and marshes. Removal of the primitive cover from stream banks invariably leads to malaria transmitted by this species. This has been a special problem on the plantations. Clearing operations in mangrove forests obstruct the natural drainage and create *sundaicus* habitats. This is an important control problem in the regions where virgin mangrove still exists.

In New Guinea, the Molukkas, and adjacent islands the "sun-loving" vectors are *punctulatus punctulatus* and *punctulatus moluccensis*. Endemic malaria centers become established in a very short period if proper control measures are not taken. The *punctulatus* hazard in operations requiring clearing cannot be overestimated.

Irrigation ditch malaria.—Poorly maintained irrigation ditches may harbor *maculatus*, *hyrcanus*, *aconitus*, *minimus* or fresh-water *sundaicus* (Sumatra only) larvae creating local malaria problems.

Occurrence of adult vectors along streams.—Recently Venhuis (1942) has studied the natural daytime resting places of some anophelines. His results show that adult *maculatus*, *aconitus*, and *minimus flavirostris* are more apt to be found in greater numbers during the day hiding along stream banks than in dwellings and stables. Furthermore it was found that the index of infection of the mosquitoes captured from stream banks is invariably greater than the indices of those taken in dwellings and stables. In this way it was possible to account for epidemics in East Java in which the anophelines captured in dwellings had unusually low indices of infection. This investigator regards stream banks as the natural daytime shelter for *maculatus*, *aconitus*, *minimus flavirostris*, *kochi*, *leucosphyrus*, *tessellatus*, and *vagus* adults. On the other hand *barbirostris*, *hyrcanus*, *annularis*, and *subpictus* are seldom collected from stream banks and are assumed to have other natural daytime resting habits. Although these experiments were made in Java it appears that the conclusions are applicable to other islands. Venhuis (1942) emphasizes the importance in surveys of collecting from stream banks as well as in dwellings and stables in order to secure reliable information on *maculatus*, *aconitus*, and *minimus flavirostris*.

Swamp malaria.—*A. hyrcanus* and *aconitus* are the species most likely to be found breeding in swamps in the

western part of the archipelago. The *punctulatus* subspecies, in the eastern part, breed in swamps when exposed to sunlight.

"Salt-making" malaria.—Salt-making activities east of Makassar (Celebes) and on Madoera obstruct the natural drainage and result in the breeding of *subpictus* and *sundaicus* and consequently severe epidemics.

Rodenwaldt (1939) lists some of the more fortunate aspects of malaria in the Netherlands Indies. There is no true "rice-field" vector i. e., one that breeds during the rice growing season; none breeds in water collected in palm leaves, plant axils, etc., or in coconut shells, small vessels, crocks, or chinks in masonry. It is possible that the *punctulatus* subspecies may occasionally constitute exceptions but as yet there is no incriminating evidence.

Notes on Malaria in the Various Islands.

The notes in the ensuing paragraphs have been gleaned from the above mentioned authors and reports and are recorded according to islands. Although they do not present a complete picture of any of the islands they do indicate the type of problems to be encountered.

Java and Madoera.—Because the population of Java and Madoera is greater than the combined populations of the other islands much more is known and much more has been written about their malaria. The principal hazards in Java are the brackish-water lagoons of the south coast and the salt-water fish ponds both of which are breeding places for *sundaicus* as well as *subpictus*. The latter species is not very important as a vector in Java.

Because the optimum salt concentration for *sundaicus* larvae is 5 to 15 parts per thousand there is a periodicity in *sundaicus* populations dependent upon the periodicity in rainfall. From January to March when there is much rain in Java the salt concentration in the fish ponds de-

creases due to dilution by rainwater and becomes optimum for *sundacius* larvae. There is then a corresponding increase in the adult *sundaicus* population. In August, because of the drier season, the salt concentration increases because of evaporation, *sundaicus* larvae decrease in numbers and eventually disappear between August and September, whereas *subpictus* may become sufficiently numerous to be a vector of importance. Particularly severe epidemics, with *sundaicus* as the vector, occur at Tandjong Priok in West Java. The severity of these is reflected by the fact that scarcely a year passes without at least one paper in the Dutch medical journals concerning the Priok epidemics.

Most of the northern coast is endemic because the removal of mangrove has resulted in the formation of *sundaicus* breeding habitats. Kuipers and Stoker (1934) described an epidemic on the north coast with *sundaicus* with a natural infection of 46 percent. Tjihea Plain, an area of 140,000 acres in West Java, constituted a serious malaria problem until the regulation of the flooding of rice fields and other control measures were begun in 1919. The rigid control program resulted in a reduction in spleen index from 88 percent in 1919 to 12 percent in 1935. The vector involved is *aconitus* whose larvae are found in flooded rice fields after the harvest. Because the control program is difficult and expensive to administer it is best to assume that the control system has broken down under Japanese occupation. Tjiandjoer Plain, 30,000 acres, presents a similar problem although complicated by freshwater fish ponds, both temporary and permanent, which harbor *aconitus* larvae unless properly controlled. Here also regulation of planting and flooding have been enforced thereby reducing malaria appreciably. *A. aconitus*, because of the large numbers of rice fields in Java and Madoera, is second in importance only to *sundaicus*.

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very part of Java has recorded *aconitus* malaria epidemics.

A. maculatus is an important local vector in the mountains of Java especially on the plantations where the cover has been removed along the mountain streams. The role of *hyrcanus* in Java is difficult to ascertain. Soesilo (1935) believes that *hyrcanus sinensis* is not important as a vector although Overbeek (1940) reports epidemics at Lamongan, Soerabaja, and Bodojonero in which *aconitus* and *hyrcanus* were the vectors. Venhuis (1942) believes *hyrcanus* X to be the *hyrcanus* vector in Java.

A. minimus and *kochi* are at the most of local importance in Java and Madoera. The recent work of Venhuis (1942) indicates that *leucosphyrus* may be of some importance.

Sumatra and adjacent islands.—The most important vector here also is *sundaicus*. As previously mentioned, there is in Sumatra a fresh-water form of *sundaicus* in addition to the brackish-water form. However its distribution is limited to the long parallel valleys of the Barisan Mountains particularly around Rau, Panti, and Padoeng Sidempoean where it breeds in lakes, ponds, and fresh-water fish ponds. Malaria is endemic along the southwestern coast of Sumatra where *sundaicus* breeds in the brackish-water lagoons. Salt-water fish ponds are not as numerous as in Java. Because of the muddy mangrove coasts on the northeast of Sumatra *sundaicus* is not numerous and the coastal mangrove strip is relatively free of malaria. The principal rice field vectors are *aconitus* and *hyrcanus*. The latter occurs commonly on the alluvial plain on the southern part of the island where it is an important vector. *A. umbrosus* is well distributed in northern Sumatra. In spite of the fact that it is an important vector in Malaya and Bangka no mention is made of it as a vector in Sumatra. In the mountains

maculatus is a vector wherever suitable streams have become exposed to sunlight. The Dutch literature contains little information on the relation of *kochi*, *minimus*, and *subpictus* to malaria in Sumatra and it is therefore assumed that they are of no more than local importance. At Soendetar in West Sumatra *leucosphyrus* is periodic with large numbers appearing in December and January as the breeding places become dry. Here it is definitely a vector. It has also been found infected at Kisaran on the east coast of Sumatra (1.7 percent) and at Loeboek-Linggan, South Sumatra (15 percent).

Riouw Archipelago, Lingga Archipelago, and adjacent islands.—There is little information on malaria in these islands in the Dutch literature. According to Boumiester (1934) *sundaicus* is the vector in the severe endemic malaria of the coastal areas. This has been controlled on some of the islands at least. The extent of these endemic coastal areas is not discussed. *A. hyrcanus sinensis* is fairly abundant and difficult to control; however, its status as a vector is uncertain. *A. maculatus* may be a vector in the mountains. At Tanjong Pinang, principal town in Riouw, it breeds in brooks, irrigation ditches, and marshy fields and is a vector of some importance. There are also records of the occurrence of *kochi*, *subpictus*, *umbrosus*, and *leucosphyrus*, although there is no information concerning their relation to malaria. It is well to bear in mind that *umbrosus* is an important vector in Bangka and in Malaya. Although there are no records for *aconitus* and *minimus* this does not necessarily preclude their occurrence.

Bangka, Billiton, and adjacent islands.—Information is very meager. Again *sundaicus* is the important coastal vector. Most malariologists mention *umbrosus* as an important vector on Bangka where there is a natural infection of 5 percent. There are records of *subpictus*,

kochi, *maculatus*, and *hyrcanus* but no information is available on their relation to malaria on these islands.

Borneo.—The sparse population, the mangrove-covered coast, and the extensive jungles make the malaria situation in Borneo considerably different from that of the other islands. There is also less information available than for any other island with a possible exception of New Guinea. Malaria is not prevalent because there are so few people. Pontionak and Bandjermasin are virtually free of malaria because of their location in mangrove areas. Tarakan Island (coast of West Borneo) has a very low incidence of malaria. *A. sundaicus* is uncommon because the coast is covered with mangrove forests. It must be assumed that this species may become numerous and important as a vector when mangrove is removed or when the natural drainage is obstructed. *A. leucosphyrus* has a rather general distribution in Borneo and is regarded by Stoker (1934) as a vector of some importance. He found natural infections as high as 6 percent at Boelongan and Poeloe Laoet. *A. umbrosus* which will breed in the drier parts of the mangrove forest in brackish water as well as in shady fresh-water bodies is regarded as a vector of possible and potential importance. It is widely distributed in the island. *A. kochi* has an extensive distribution in Borneo but there is no information on its relation to malaria. There are a few records of *aconitus*, *maculatus*, and *subpictus* but no further information.

Lesser Soenda Islands (as far east as Roma).—The coastal areas of these islands frequently have endemic malaria due to *sundaicus* similar to that of Java. The salt-water lagoons which are said to occur on most of these islands particularly on the southern shores are the breeding habitats. These lagoons are said to be best developed in those islands with an open exposure to the southerly winds. Rodenwaldt (1939) states that there is endemic

malaria in the coastal areas of "many of the Lesser Soenda Islands." Further information does not appear in the literature. Collecting records show that *subpictus*, *kochi*, *minimus*, *aconitus*, and *maculatus* occur on many or most of these islands. There is no information as to their abundance or relation to malaria.

Celebes and adjacent islands.—Makassar in Celebes is occasionally reported as relatively free of malaria. Whether this is a natural condition or due to control measures cannot be ascertained. Certainly at times malaria is prevalent there. Until recent years the principal coastal anopheline has been *subpictus*. However, *sundaicus* has now become established in southern Celebes and adjacent islands where it is the cause of severe epidemics. How rapidly this species is extending its range northward is not known. *A. minimus flavirostris* has been found infected at Minahassa although there is no further information concerning its role as a vector. Brug (1937) has reported *bancroftii* from Celebes although he states that here, in contrast to its habits in New Guinea, it is not anthropophilic. In 1938 he described the Celebes *bancroftii* as a taxonomic entity, *Anopheles bancroftii barbiventris*. *A. subpictus* because of its large numbers is frequently involved in epidemics. Its low potential infection prevents it from becoming as serious a vector as *sundaicus*. The roles of *leucosphyrus*, *umbrosus*, *kochi*, and *aconitus* in malaria transmission in Celebes are not discussed in the literature.

The Molukkas and adjacent islands (including Soela and Ceram).—On all of these islands the important vector is *punctulatus* (*punctulatus* and *moluccensis*) which as described elsewhere in this report is an ubiquitous sunlight breeder. However these islands are in the transition zone between Australia and Asiatic fauna hence some of the Asiatic vectors also occur. *A. umbrosus* has been

reported from Boeroe; *kochi* from Boeroe, Halmahera, Ambon, and Soela; and *subpictus* from Boeroe, Halmahera, Ambon, Soela, and other islands. The typical *ludlowi* of the Philippines has been reported from Ceram. All of these species may be of some importance as vectors although the principal problem is *punctulatus*.

New Guinea and adjacent islands.—Although information is somewhat meager it can be emphasized with certainty that the important vectors, both on the coast and in the interior, are *punctulatus punctulatus* and *punctulatus moluccensis*. The role of *bancroftii* is uncertain. De Rook (1938) has discussed extensively the prevalence of malaria in New Guinea on the basis of available information. According to him the entire north coast of New Guinea is an area of high endemicity; spleen indices vary from 30 to 100 percent, with 60 to 80 percent in most localities. The same is true for the entire coast, north and south, of Vogelkop ("the Birdhead"). In general along MacCluer Gulf and Argoeni Bay on the south shore of New Guinea malaria is prevalent although not to the same extent as on the north shore; spleen indices of 30 to 70 percent are recorded. At some places between Kaimana and Atoeka on the southern coast the incidence is very low. The spleen indices at the mouth of the Atoeka River were 3 to 4 percent in 1932. According to de Rook, "The small amount or complete lack of malaria in some villages on the southwest coast is probably associated with local conditions such as the ebb and flow of the tide which do not allow suitable breeding places." Nevertheless the danger of "man-made" *punctulatus*-borne malaria is always imminent in any kind of operations. Spleen indices for Frederik-Henrick Island vary from 9 to 14 percent. Benign tertian malaria is prevalent in the Mamberamo River Valley and in the Upper Digoel region. The immediate region of the Mamberamo River is highly en-

demic. Little is known of malaria conditions in the mountains although malaria is known to be endemic as high as 3,500 to 4,000 feet. Tenah Merah, formerly highly endemic, has been improved by elimination of *punctulatus* breeding places.

Malaria Control in the Netherlands Indies.

The Dutch have employed extensive and ingenious methods of control in their antimalaria program. Whether or not these controls are still in operation during the Japanese occupation is a matter of speculation. Although most of the methods employed are not applicable to military operations nevertheless the possibility of their use prompts the inclusion of a brief discussion of them. They are the products of many years' experience in malaria control in these areas. The principal problem has always been the control of the breeding places of *sundaicus* i. e., salt-water fish ponds and brackish-water lagoons (also fresh-water ponds in Sumatra).

Brackish-water lagoons.—Apparently the most successful control has been obtained by connecting these lagoons with the ocean thereby raising the salt concentration and bringing the water under tidal influence both of which are detrimental to *sundaicus* larvae. Oiling has been unsuccessful because of wind action. Filling has been practical only to a limited degree because of the expense involved.

Salt-water fish ponds.—These ponds normally have a surface flora of filamentous green algae which harbors *sundaicus* larvae. Here again connecting to the ocean has been practiced successfully on the same basis as in control of brackish-water lagoons. A further measure when practicable is the monthly drainage system ("hygienic control"). During the period of drainage the fish remain in a specially constructed circular moat around the edge

of the pond. During this time the algae die in the sun; complete drainage is not necessary since sunlight is lethal to the algae in shallow water. When the pond is refilled there are no surface green algae and the *sundaicus* larvae population is reduced. In the meantime a bottom flora of blue-green algae has developed which provides food for the fish without harboring *sundaicus* larvae. Zon (1939) states that 70 to 99 percent of the *sundaicus* larvae can be eliminated by this method. Flooding and drainage is accomplished by the use of tidal flood gates.

Rice fields.—The Dutch have enforced simultaneous planting and harvesting and have required immediate drainage of the fields after the harvest. In addition there has been strict supervision of the irrigation and drainage systems. This program has given good results since it prevents the breeding of *aconitus* and *hyrcanus*. Its application is difficult in localities where the fields are used as temporary fish ponds after the harvest. Periodic drying (nine days watering and two days draining) is also employed during the growing season in some localities.

Fresh-water fish ponds.—If rice fields are used as temporary fish ponds the best control has been found to be the removal of all straw or at least the stacking of it in large piles before flooding and the keeping of the banks free of vegetation. Walch and Soesilo (1935) describe the introduction of herbivorous fish which feed on the filamentous green algae and the introduction of the larvivorus species, *Panchax panchax*, which feeds on the larvae when they are unable to take refuge among the algae.

The *punctulatus* problem.—Control of the two subspecies of *punctulatus* has been based on the habits of the species and consists of the elimination or control of all bodies of water exposed to sunlight.

Malaria control among the natives is difficult to practice because of their objection to the use of screens and netting. Also the walls of the native dwellings frequently are not mosquito-proof.

Blackwater Fever

Blackwater fever occurs sporadically throughout the archipelago. It has been noticed particularly among Japanese fishermen who have been in the area for a relatively short period of time. There are reports of cases from Celebes, Flores, Lombok, New Guinea, Sumatra, and Java.

Chapter III

FILARIASIS

Two species of human filarial worms, *Wuchereria bancrofti* and *Wuchereria malayi*, are known to occur in the Netherlands Indies. The best sources of information on filariasis in this area are the papers of Brug who originally described the microfilariae of *malayi* and who has written extensively on the geographical distribution of both species. He has also discussed the clinical aspects of filariasis in the Netherlands Indies.

According to Brug (1931) there is an interesting difference in the nocturnal periodicity of the two species. The ratio of microfilaria in the peripheral blood during the day as compared to night is about 1:15 for *malayi* as compared to 1:100 in *bancrofti*. The relation of *malayi* and *bancrofti* to the clinical aspects of filariasis is not well understood. Brug (1933, 1937) states that in general *malayi* infections result in elephantiasis of the limbs whereas *bancrofti* infections are more apt to cause hydrocele and genital elephantiasis. There is also no consistent correlation between microfilariae indices and the clinical manifestations of filariasis. Some areas with high *malayi* indices have a high incidence of elephantiasis, whereas other areas with similar indices may have a low incidence of elephantiasis. Some surveys show that the actual cases of elephantiasis may have a higher microfilaria index than the general population although more frequently the opposite appears to be true. In general filariasis appears to be primarily a disease of the plains although there are numerous exceptions to this.

FIG.3 Filariasis Surveys in the Netherlands Indies

TABLE 6.—*Summary of filariasis surveys compiled from Brug (1931), Brug and de Rook (1933) and other sources*

Locality	Number examined	Index of infection			
		malayi	*bancrofti*	Not determined	Total
Kotta Radja (Atjeh, Sumatra)	83	4%	5%	--------	8%
Leumpotong Rajoet (Atjeh, Sumatra)	81	12%	3%	--------	16%
Seulimeum (Atjeh, Sumatra)	26	8%	4%	--------	12%
Sigli (Atjeh, Sumatra)	87	6%	13%	--------	18%
Lho Semawe (Atjeh, Sumatra)	1,300	--------	--------	1%	1%
Idi (Atjeh, Sumatra)	23	--------	--------	43%	43%
Tapa Toean (Atjeh, Sumatra)	42	0	0	0	0
Bakongan (Atjeh, Sumatra)	21	--------	--------	29%	29%
Meulaboh (Atjeh, Sumatra)	101	--------	--------	18%	18%
Meulaboh (Atjeh, Sumatra)	62	32%	--------	1%	32%
Simaloer (Atjeh, Sumatra)	34	0	0	0	0
Kota Singkel (Atjeh, Sumatra)	60	--------	--------	3%	3%
Roedeng (Atjeh, Sumatra)	56	>12%	<27%	27%	39%
Lipat-Kandjang (Atjeh, Sumatra)	40	>10%	<7%	7%	17%
Below Singkel (Atjeh, Sumatra)	32	--------	--------	1%	1%
Simpang Kanan (Atjeh, Sumatra)	50	--------	--------	14%	14%
Simpang Kiri (Atjeh, Sumatra)	88	--------	--------	40%	40%
Troemon	11	--------	--------	36%	36%
Ma. Tambesi (Djambi, Sumatra)	271	--------	--------	18%	18%
Ramboetan Asem (Djambi, Sumatra)	64	6%	--------	--------	6%
Sarolangoen	146	8%	8%	--------	13%
Mentawei E. (West Coast Sumatra)	151	0	0	0	0
Padang (West Coast Sumatra)	100	0	0	0	0
Aer Proekan and Dermajoe (Benkolan, Sumatra)	131	54%	--------	--------	54%
	84	37%	--------	--------	37%
Benkoelan (Benkoelan, Sumatra)	780	8%	--------	--------	8%
	37	8%	--------	--------	8%
Siboehoean (Tapanoeli, Sumatra)	--------	mostly *bancrofti*			44.1%
Indragiri Plateau (Sumatra)	519	18%	--------	--------	18%
Nias (West of Sumatra)	--------	70%	--------	--------	70%
Goenoeng Pajoeng (Benkoelen, Sumatra)	12	58%	--------	--------	58%
Passar Lais (Benkoelen, Sumatra)	50	6%	--------	--------	6%
Doesoen Radja (Benkoelen, Sumatra)	50	18%	--------	--------	18%
Moko-moko (Benkoelen, Sumatra)	47	17%	--------	--------	17%
Ketaun Plain (Benkoelen, Sumatra)	1,789	2%	--------	--------	2%
	226	1%	--------	--------	1%
Java (no locality given)	1,482	--------	--------	5%	5%
Java (no locality given)	701	--------	--------	3%	3%
Java (no locality given)	100	0	0	0	0
Java (no locality given)	291	--------	1%	--------	1%
Weltevreden (Java)	?	--------	+	--------	?

TABLE 6.—*Summary of filariasis surveys compiled from Brug (1931), Brug and de Rook (1933) and other sources*—Continued

Locality	Number examined	Index of infection			
		malayi	*bancrofti*	Not determined	Total
Java (no locality given)	145			3%	3%
Soemenep (Madoera)	56	0	0	0	0
Sampang (Madoera)	30	0	0	0	0
Djenparing (Borneo)	21	33%	43%		57%
Kendangan (Borneo)	121	23%			23%
M. Moening (Borneo)	140	33%			33%
M. Moening (Borneo)	24	2%			2%
Rantan (Borneo)	188	48%			48%
Rantan (Borneo)	104	23%			23%
Sampoer (Borneo)	200	35%			35%
Margasari (Borneo)	104	29%			29%
Bliman (Borneo)	54	35%			35%
Negara (Borneo)	104	10%			10%
Makassar (Celebes)	263	0	0	0	0
Makassar (Celebes)	300	0	0	0	0
Tjenrana, Tenggelang, Tobango (Celebes)	69			12%	12%
Coast of Madjene (Celebes)	240	0	0	0	0
South District (Celebes)	222	18%	5%		20%
North District (Celebes)	808	27%			27%
Pinrang Kaloepang (Celebes)	35	17%			17%
Tiroeang (Celebes)	42	42%			42%
Lassape (Celebes)	15	40%			40%
Simpang (Celebes)	68	15%		1%	16%
Kawata Tampango (Malili, Celebes)	118	28%			28%
Posso & Parigi (Celebes)	130	0	0	0	0
Minahassa (Celebes)	117	0	0	0	0
Wadjo Solotenga (Celebes)	21	57%			57%
Wadjo Lempong (Celebes)	123	60%			60%
Kawata (Celebes)	10	20%			20%
South Paloe Plain (Celebes)	668	62.1%			62.1%
North Paloe Plain (Celebes)	266	12.7%			12.7%
Palolo Region (Celebes)	97	14.4%			14.4%
Palawa Region (Celebes)	160	11.8%			11.8%
South Benawa (Celebes)	62	58.0%			58.0%
Koelawi Region (Celebes)	545	*1.8%			1.8%
Donggala Region (Celebes)	305	24.2%			24.2%
Panigi (Celebes)	457	20.9%			20.9%
Kamaroe (Boetoeng Island)	7	4 cases *bancrofti*			
Ereke (Boetoeng Island)	8	6 cases *bancrofti*			
Bave Bave (Boetoeng Island)	39	0	0	0	0
Moa	28		7%		7%
Kesar, Leti, Sermata	223	0	0	0	0

* This survey includes several villages with indices varying from 0 to 32 percent.

TABLE 6.—*Summary of filariasis surveys compiled from Brug (1931), Brug and de Rook (1933) and other sources*—Continued

Locality	Number examined	Index of infection			
		malayi	*bancrofti*	Not determined	Total
Kabaena Island	96	--------	--------	29%	29%
Ilwaki (Wetar Island)	115	--------	38%	--------	38%
Hila (Roma Island)	54	--------	6%	--------	6%
Soemba Island	70	10%	10%	--------	17%
West Soemba	582	20%	1%	--------	20%
Middle Soemba	213	10%	3%	--------	13%
East Soemba	359	7%	6%	--------	13%
Wakoe Seko (Flores)	53	11%	2%	--------	11%
Wakoe Seko (Flores)	107	20%	9%	--------	22%
Moekoe Saki (Flores)	60	2%	35%	--------	35%
Moekoe Saki (Flores)	55	7%	55%	--------	55%
Maoe Role (Flores)	90	17%	21%	--------	27%
Maoe Sambi (Flores)	28	11%	--------	--------	11%
Maoe Sambi (Flores)	72	25%	8%	--------	28%
Potta (Coast, Flores)	36	3%	31%	--------	36%
Bari (Coast, Flores)	32	3%	6%	--------	9%
Biting Ketjil (Coast, Flores)	32	6%	34%	--------	37%
L. Badjo Ketjil (Coast, Flores)	46	0	0	0	0
26 villages (1,000-3,000 ft., Flores)	860	0	0	0	1%
Limboer (Alor)	15	4 cases, undifferentiated			
Limboer (Alor)	25	--------	--------	20%	20%
Wae-Apo Plain (Boeroe)	832	--------	51.8%	--------	51.8%
Omstr. Limboer	95	--------	--------	8%	8%
Atamboea (Timor)	56	2%	--------	--------	20%
Soea (Rotti)	22	--------	--------	73%	73%
Warasiva (Ceram, Molukkas)	50	0	0	0	0
Hatenoeroe (Ceram, Molukkas)	44	14%	--------	--------	14%
Ceram—North Coast from opposite Piroe to Wahaai (30 villages)	1394	0–62% (12%)	--------	--------	0–62% (12%)
Manokwari (New Guinea)	91	--------	16%	4%	20%
Manokwari (New Guinea)	63	--------	--------	35%	35%
Fak fak (New Guinea)	79	--------	1%	--------	1%
Fak fak (New Guinea)	37	--------	16%	--------	16%
Upper Digoel (New Guinea)	216	--------	11%	--------	11%
Upper Digoel (New Guinea)	145	--------	4%	--------	4%
Upper Digoel (New Guinea)	32	--------	25%	--------	25%
Wassoir	36	--------	42%	--------	42%
Miei	23	--------	61%	--------	61%
Koebiari	23	--------	61%	--------	61%
Makboen	95	--------	45%	--------	45%
Saosopar	75	--------	33%	--------	33%
Saosar	63	--------	35%	--------	35%

TABLE 6.—*Summary of filariasis surveys compiled from Brug (1931), Brug and de Rook (1933) and other sources*—Continued

Locality	Number examined	Index of infection			
		malayi	*bancrofti*	Not determined	Total
Seged	140	--------	83%	--------	48%
Noemfoor Island	73	--------	4%	--------	4%
Koholombo (New Guinea)	93	--------	13%	--------	13%
Wap (New Guinea)	64	--------	6%	--------	6%
Inawattan (New Guinea)	251	--------	50%	--------	50%
Inawattan (New Guinea)	33	--------	58%	--------	58%
Hollandia (New Guinea)	--------	--------	20%	--------	20%

It is apparently safe, and certainly most advisable, to assume that all of the islands harbor vectors for *malayi* or *bancrofti* or both. However, the incidence of filariasis and its geographical occurrence can by no means be explained entirely by the geographical distribution of the vectors. Compilation of survey data from Brug (1931, 1933, 1937) and others (table 6, p. 54, and fig. 3) gives a general concept of the geography of filariasis although the picture is incomplete because of unsurveyed areas. The known geographical occurrences of *malayi* and *bancrofti* are approximated in figure 4. According to Brug (1931) *malayi* probably occurs throughout the archipelago except on New Guinea and adjacent islands; *bancrofti* is prevalent in the eastern part of the archipelago and sporadic elsewhere.

Although the data are fragmentary it is possible to designate certain areas as endemic. Atjeh in northwestern Sumatra is a notoriously endemic area. *Wuchereria malayi* is the more abundant species although some *bancrofti* cases are reported. Benkoelan, Djambi, and Indragiri in Sumatra are endemic areas from which *malayi* only has been reported. Nias, off the west coast of Su-

FIG. 4 Distribution of *Wuchereria bancrofti* and *Wuchereria malayi*

matra, is highly endemic. Surveys on Simeuloeë and Siberoet have given negative results.

Filariasis is only sporadic in Java except on the Serajoe Delta where it is endemic. Surveys on Madoera have been negative. The literature contains no references to filariasis in Lombok, Bali, and Soembawa. Since these islands are heavily populated and have been carefully studied it seems logical to assume that if filariasis were present to any degree it would be recorded in the literature.

In the eastern Lesser Soenda Islands filariasis is prevalent. There is a transition from the mixed *bancrofti* and *malayi* indices of Flores and Soemba to the exclusively *bancrofti* indices of Wetar and Roma. The Lesser Soenda Islands from Flores eastward should be considered endemic or potentially endemic areas. Filariasis is apparently highly endemic in the eastern Lesser Soenda Islands.

Extensive surveys in South-East Borneo have revealed filariasis to be very prevalent; *malayi* is widespread whereas *bancrofti* is sporadic. There is no other information from Borneo except records of elephantiasis (*malayi*?) from West Borneo.

Filariasis is very prevalent on most of Celebes; the vast majority of the cases are *malayi* with very little *bancrofti*. Makassar and Menado (City) have been reported free of filariasis. The prevalence in the Residency of Menado (northern peninsula) is probably low. The island of Kabaena south of Celebes is highly endemic (*bancrofti*) and filariasis is also prevalent on nearby Boetoeng where only *bancrofti* has been reported.

In the Molukkas, Ceram, especially the northern coast, is reported to be highly endemic; only *malayi* has been found. The Wai-Apo Plain on Boeroe is also a region of high endemicity although only *bancrofti* has been reported here. Elephantiasis has been reported as prevalent in Ambon. There is no information from Halmahera and

adjacent islands. Reports in the *Mededeelingen van den Dienst der Volksgezondheid in Nederlandsch Indië* (1927) indicate that filariasis occurs in the Soela Islands as well as in the Tanimbar Islands.

All surveys on New Guinea and adjacent islands have reported high indices of *bancrofti; malayi* has never been reported. Although reports are fragmentary it appears that all of New Guinea and its adjacent islands should be regarded as highly endemic areas.

Filariae Vectors

The subject of filariae vectors in the Netherlands Indies as in other areas is difficult. The literature is confused because of the failure of some authors to detect whether or not larval development was complete in designating a mosquito as a vector. Furthermore, much of the information in the literature is based on experimental infections and it does not necessarily follow that species which can be infected experimentally are actually natural vectors. However careful correlation of microfilaria indices in the population and larval indices in the mosquitoes have given good results in some instances. The role of culicines in filariasis is best summarized by Bonne-Wepster and Brug (1937) and the anopheline vectors of filariae by Brug (1937, 1938). Nevertheless the filariae vector situation is sufficiently unclarified to prompt Brug (1937) to state that until the vector is definitely incriminated in an area that it may be best to control all species of mosquitoes which are known to attack man. Furthermore, the information on the geographic distribution of the filariae vectors is not as extensive as that for the malaria vectors. In general only references to islands are available with no data as to the distribution or abundance on the island.

Above all it is necessary to remember that there is still much to be learned about the transmission of filariae in

this area and that the information compiled here will without a doubt ultimately prove to be fragmentary.

Wuchereria malayi Vectors.

Mansonia (Mansonioides).—Several species of this subgenus are known to be vectors. The imagoes of this group are easily recognized by the broad asymmetrical erect wing scales. The wings, except in *papuensis*, are distinctly light and dark mottled. All species are of medium size except *papuensis* which is rather small. The abdomen of the female is turned up at its distal end with only 6½ segments visible in the dorsal view. The apical segment of the male proboscis is turned downward; the penultimate is turned upward. The male has the 8th abdominal segment entirely retracted and the hind margin of this segment bears closely set strong teeth differing in the various species. The male hypopygia all have a peculiarly modified basal lobe, a simple mesosome and tenth sternites with strong teeth at the apex.

The larvae and pupae live with their peculiarly modified breathing tubes attached to roots or sometimes to the leaves of water plants. Formerly (Bonne-Wepster, 1930) the Dutch believed the only host plant to be *Pistia*, principally *striatioles*. However English investigators also indicate *Lemna* as a host plant and more recently Bonne-Wepster (1937) has added *Eichhornia crassipes*. The breathing tubes penetrate into the tissue of the roots and during larval and pupal life oxygen is obtained from the tissues of the host plant. To find the larvae it is necessary to collect a large number of *Pistia* plants and shake each one vigorously in clean water. In this way the larvae and pupae can be detached and caught. Normally the pupae become detached only just preceding the emergence of the imago.

The female deposits the eggs on the leaves of the host plant in a rosette-shaped figure.

From the standpoint of control it is important to bear in mind that *Mansonioides* species are restricted in their distribution to the distribution of the host plants, *Pistia*, *Eichhornia* and possibly others, and that ordinary survey methods will not detect the presence of the larvae and pupae.

Pistia and *Eichhornia* are floating aquatic plants. They are found in ponds, lakes, and slowly flowing streams. They are abundant throughout the tropics.

1. **M. (M.) annulata.**—According to Bonne-Wepster (1937) the females of this species have been found in great numbers where there are no *Pistia* plants. Therefore it is possible that another host plant is involved. The larvae have not been found. The adults enter dwellings in tremendous numbers and attack man. On rainy evenings particularly they are attracted to lights where they are frequently killed in large numbers. According to Bonne-Wepster and Brug (1937) *malayi* larvae develop completely and become infective in this species and therefore it is to be regarded as an important vector. In the Netherlands Indies it has been reported only from restricted areas on Sumatra and Celebes (fig. 5). Bonne-Wepster and Brug (1937) state that it is the most numerous mosquito at Dermajoe (Benkoelen, Sumatra).

2. **M. (M.) indiana.**—This species is known to breed on *Pistia* only. It is strongly anthropophilic. Bonne-Wepster and Brug (1937) describe it as a good vector of *malayi*. Rodenwaldt (1934) mentions *indiana* and *annulifera* as the filariae vectors on the Serajoe Delta in Java. This species has been recorded from Sumatra, Bangka, Java, Flores, and New Guinea (fig. 5). Specimens from Upper Digoel have less white on fore and middle femora.

3. **M. (M.) uniformis.**—*Pistia* and *Eichhornia* have been reported as host plants for this species. Bonne-Wepster and Brug (1937) describe the complete development of *malayi* larvae in this species and state that it is

FIG. 5 Distribution of *Mansonioides* mosquitoes in the Netherlands East Indies

a good vector. *M.* (*M.*) *uniformis* is the most common of the *Mansonioides* species.

Kariadi (1938) reported *uniformis* numerous at Martapoera (Borneo) where *malayi* indices are high. It is reported by Scheepe (1935) as one of the vectors in Indragiri (Sumatra).

In the Netherlands Indies it has been found in Sumatra, Simaloer, Nias, Riouw, Java, Borneo, Ceram, Boeroe, and New Guinea (fig. 5).

4. **M. (M.) longipalpis.**—The breeding biology of this species, so far as known, is the same as that of *annulata*. Bonne-Wepster and Brug (1937) describe *longipalpis* as an important vector of *malayi*. It has been reported in Sumatra, Nias, Bangka, Verlaten Island, Java, Borneo, Tarakan Island, Celebes, Boeroe, and Halmahera (fig. 5).

5. **M. (M.) annulifera.**—This mosquito also has been reported only from *Pistia*. It is strongly anthropophilic and according to Bonne-Wepster and Brug (1937) a good vector of *malayi*. This species as well as *uniformis* was reported by Kariadi (1938) as abundant at Martapoera where filariasis is prevalent. It is also one of the vectors in Indragiri (Sumatra) according to Scheepe (1935).

M. (M.) papuensis and **M. (M.) bonneae** are rare species and nothing is known of their relation to filariasis; *papuensis* has been reported only from New Guinea and *bonneae* only from Borneo and Malaya. The same is true for **M. (M.) negrochracea** and **M. (M.) memorans** also known only from New Guinea.

Myzorhynchus series.—At least three members of this group of the subgenus *Anopheles* are vectors of *malayi*. These are *A. barbirostris*, *A. hyrcanus sinensis*, and *A. hyrcanus* X of Venhuis.

6. **Anopheles barbirostris.**—This is the most im-

portant anopheline vector of *malayi.* The larvae are ubiquitous in fresh water but are seldom found in brackish water. They are most commonly encountered in rice fields but also are found in slowly flowing rivers and creeks (near the banks), fish ponds, marshes, ditches, springs, and buffalo wallows. They are found in clear as well as stagnant and turbid water. Sunlight and shade do not seem to be factors. The species occurs both in the mountains and near the coast.

In general the adults are not numerous around dwellings and are said to be primarily zoophilic. However Brug (1937) reports the *barbirostris* at Kalawara (Celebes) to be very anthropophilic. Rodenwaldt and Swellengrebel (1932) report it as a house mosquito in a village near a marsh on Soemba. It is also reported to be a persistent house mosquito on Wetar and at Tegal (Java). Walch (1930) reported 12 percent to have human blood where livestock is abundant and 31 percent elsewhere.

Brug (1937), Bonne-Wepster and Brug (1937), Machsoes (1939), Jurgens (1932), and Kariadi (1941) all describe *barbirostris* as a good *malayi* vector. It is especially important on Celebes where it is so persistently anthropophilic.

Anopheles barbirostris is known to occur on Java, Sumatra, Borneo, Celebes, Mentawei, Siberoet, Bangka, Riouw, Bali, Moena (Raha) Sangihe, Salajar, Wetar, Kisar, Flores, Alor, Soembawa, and Soemba (fig. 6).

7. **Anopheles hyrcanus sinensis.**—The taxonomic status of *hyrcanus* and closely related species is discussed in the section dealing with malaria vectors (page 21). The information on the larval habitats as well as the habits of the imagoes as given in the discussion of the *hyrcanus* group are in general applicable to *hyrcanus sinensis.* This subspecies is essentially a rice field and swamp breeder although larvae have been recorded from a variety of

other fresh-water habitats. This subspecies has been reported as a vector in China (Brug, 1937) and has been reported once as naturally infected in the Netherlands Indies. It can be experimentally infected with the filaria larvae, with complete development of the larvae to the infective stage. Because of the confusion in taxonomy of the *hyrcanus* group in the Netherlands Indies the exact distribution of *sinensis* is not known. The only accurate records are from Java and Sumatra although it may be of wider distribution (fig. 6).

8. **Anopheles hyrcanus X.**—This form is mentioned in the recent Dutch literature as occurring in Borneo in the region around Martapoera. It has been described by Venhuis (1939) who states that it occurs in Java and Celebes as well as in Borneo. As yet it has not been described as a separate taxonomic entity. Kariadi (1941) reported it to be a *malayi* vector at Martapoera where filariasis (*malayi*) is highly endemic. Whether or not this form has a wider distribution than the region around Martapoera and in Java and Celebes is not recorded in the literature (fig 6).

Other members of the series *Myzorhynchus*, subgenus *Anopheles*, known to occur in the Netherlands Indies, are *A. hyrcanus nigerrimus*, *albotoeniatus*, *barbumbrosus*, *bancroftii*, *hunteri*, *montanus*, *novumbrosus separatus*, and *umbrosus*. None of these have been reported as vectors.

Wuchereria bancrofti Vectors.

1. **Culex fatigans (=quinquefasciatus).**—This species is universal in its distribution in the tropics and subtropics and ubiquitous in its breeding habits. Larvae are found in all sorts of artificial accumulations of water such as tanks, wells, pits, water barrels, toilets, fountains, cisterns, ponds, springs, canals, and ditches. Generally they breed near dwellings. The larvae can withstand a salt

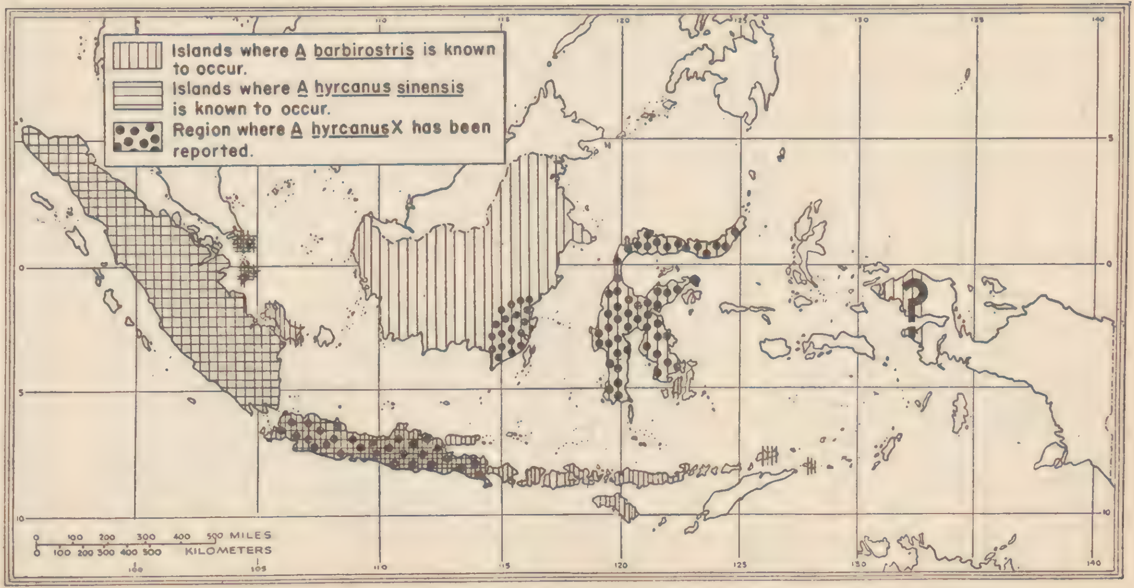

FIG. 6 Distribution of *Myzorhynchus* (subgenus *Anopheles*) anophelines known to be vectors of *Wuchereria malayi* in the Netherlands Indies..........

concentration of one part per thousand. Stagnant water is preferred. This species does not occur in the jungles and uninhabited areas.

Although standard textbooks such as Stitt, Brumpt and Manson regard *Culex fatigans* (=*quinquefasciatus*) as a foremost vector of filariae Bonne-Wepster and Brug (1937) do not feel that that is true in the Netherlands Indies. They support their conclusion with the well established observation that filariasis is primarily a disease of the plains and rural areas whereas *fatigans* occurs most abundantly in villages and cities. Furthermore de Rook (1930) has shown that *Culex fatigans* (=*quinquefasciatus*) does not occur in areas in New Guinea where filariasis (*bancrofti*) is very prevalent. He believes that *A. punctulatus* is the most important vector in New Guinea and that the role of *fatigans* is relatively minor. Bonne-Wepster and Brug (1937) strengthen their argument by showing that there is no relation between the geographical distribution of filariasis and the distribution of *fatigans*. Brug (1938) has also shown that frequently the index of infection of *fatigans* in endemic areas is not sufficiently high to warrant designating it as the most important vector. However in some endemic areas in the Netherlands Indies it is the only vector known to occur. It seems best therefore to regard it as an important vector but not with the degree of importance attributed to it elsewhere. *Culex fatigans* (=*quinquefasciatus*) has been found on Sumatra, Simaloer, Nias, Riouw, Bangka, Java, Edam, Madoera, Karimar, Djawa Island, Borneo, Tarakan, Poeloeh Laoet, Celebes, Taland Island, Banggai Archipelago, Boetoeng, Bali, Soemba, Flores, Adonare, Alor, Timor, Ceram, Ambon, Saparoea, Vanda, Aroe, and New Guinea (fig. 7).

2. **Culex vishnui.**—This species has been reported once by Brug (1938) to be infected with *bancrofti* larvae.

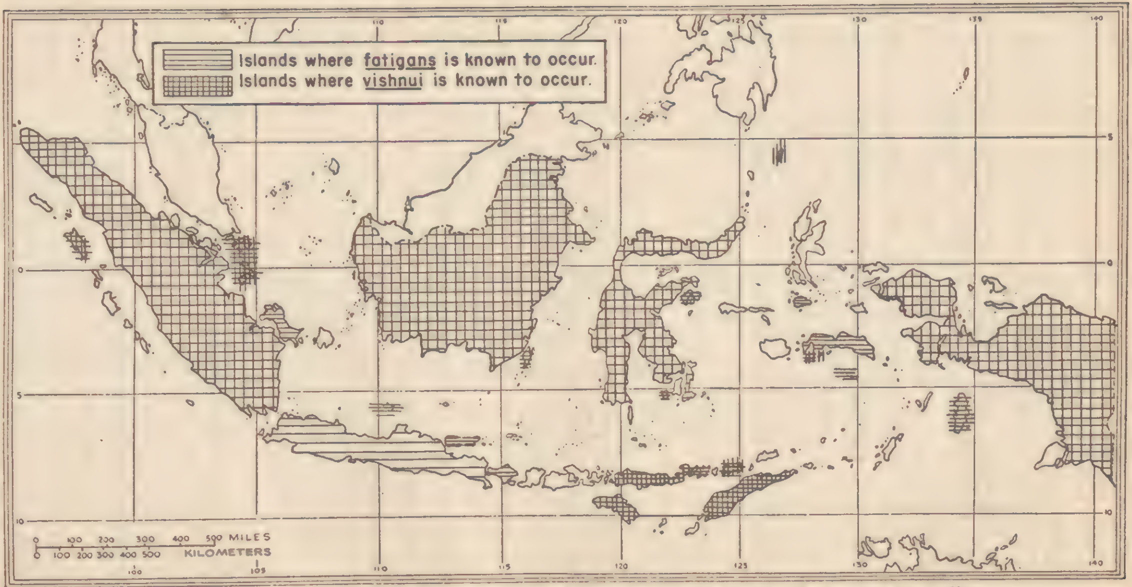

FIG. 7 Distribution of Culex fatigans and Culex vishnui in the Netherlands Indies

This index of infection of 1.5 percent was found in Kabaena Island near Celebes. Brug (1938) also was able to infect the adults experimentally. It has been reported as a vector in India. *Culex vishnui* breeds in various types of habitats but only those which are surrounded by earth such as lakes, river backwater, small streams, drainage ditches, flooded grass land, irrigation water on rice fields, lagoons, etc. It breeds infrequently in brackish water. The adults are anthropophilic and begin biting as soon as it is dark. Apparently this species is not to be regarded as an important vector in the Netherlands Indies until there is further evidence. There are reports of its occurrence on Sumatra, Riouw, Nias, Bawean, Borneo, Celebes, Flores, Soemba, Alor, Timor, Ambon, Sangihe Islands, and New Guinea (fig. 7).

Brug (1938) has been able to obtain experimental infections and complete development of *bancrofti* larvae in *C. fuscocephalus*, *C. whitmorei*, and *C. annulirostris*. His papers indicate that *C. tritaeniorhynchus*, *bitaeniorhynchus*, and *sitiens* may possibly be experimental vectors. None of these species has been found naturally infected.

3. **Anopheles punctulatus moluccensis.**—This subspecies is regarded by de Rook (1930, 1938) and Taylor (1939) as a good *bancrofti* vector. De Rook regards it as the most important vector in New Guinea. Backhouse (1934) reported good experimental infections with it. Elsbach (1939) states that *moluccensis* is the important vector in southern New Guinea.

The breeding habits and distribution of *moluccensis* are described in the section concerning malaria vectors (p. 25 and fig. 9, Appendix C).

4. **Anopheles punctulatus punctulatus.**—This subspecies is also reported as a *bancrofti* vector by Taylor (1938). Backhouse (1934) reported successful experimental infection with it. Elsbach (1939) regards *punctulatus*

punctulatus as "probably" a vector in southern New Guinea.

The breeding habits and distribution of *punctulatus punctulatus* have been described in the discussion of its role as a malaria vector (p. 27 and fig. 9, Appendix C.)

5. **Anopheles bancroftii.**—De Rook (1938) reported this species as a vector in New Guinea. Information on its breeding habits and distribution are given elsewhere. (p. 29 and fig. 10, Appendix C).

6. **Anopheles leucosphyrus hackeri.**—Brug (1938) found 3 out of 37 specimens of this subspecies infected in Kabaena Island. This is the only information on its relation to filariasis. Its breeding habits and distribution are discussed in relation to its role as a malaria vector (p. 24 and fig. 7, Appendix C).

7. **Anopheles aconitus.**—Brug (1938) also found this species naturally infected on Kabaena and obtained successful experimental infections. He does not express an opinion on its role as a vector. For information on its habits and distribution the section on malaria vectors should be consulted (p. 17 and fig. 3, Appendix C).

Soewadji Prawirohardjo (1939) has reported experimental infection in *A. sundaicus*, *subpictus*, *annularis*, *barbirostris*, *vagus*, and *tessellatus*. There are no records of natural infection in these species. Taylor (1938) reports *A. amictus* which occurs in New Guinea as a possible vector. Heyden (1931) had previously reported it as a vector in Queensland. *A. hyrcanus nigerrimus* has been reported as a vector in Malaya, and *hyrcanus sinensis* in India. *A. philippinensis*, *pallidus*, and *varuna* have also been reported as vectors in India. Brug (1938) obtained experimental infections in *A. barbirostris* and "probably" *maculatus*.

Aëdes scutellaris was regarded as a vector in the Netherlands Indies by Flu (1921, cited by Brug, 1938). How-

ever Bonne-Wepster and Brug (1937) do not regard it as such. It is a *bancrofti* vector in the Fiji Islands where the microfilariae appear in the peripheral blood during the day. In the Netherlands Indies it has a wide distribution and breeds in all sorts of habitats including brackish water, crab holes, puddles in coral reefs, depressions in old lava flows, etc. It has been reported from New Guinea, Ceram, Ambon, Boeroe, Saparoea, Sanana, Aroe Islands, Tanimbar Islands, Alor, Adonare, Soemba, Celebes, Sangihi Islands, Boetoeng, Kleiner Paternoster Islands, and Sumatra.

Aëdes vigilax has been reported as a possible vector in Australia. This species has a general distribution in the Netherlands Indies. It breeds in fresh water, brackish water, and even undiluted sea water. The adults can fly 10 to 20 miles and even 40 to 50 miles. Although it is very anthropophillic in Australia Bonne-Wepster and Brug (1937) state that this is not true in the Netherlands Indies. In the Netherlands Indies it has been recorded from Krakatau, Verlaten Island, Java, Edam, Madoera, Celebes, Flores, Aroe Islands, Tanimbar Island, and New Guinea.

None of the *Mansonioides* mosquitoes is a *bancrofti* vector in the Netherlands Indies.

SYNOPSIS OF THE KNOWN NATURAL FILARIASIS VECTORS OF THE NETHERLANDS INDIES

Vector	Geographic distribution in Netherlands Indies	Breeding habitat
Mansonia annulata	Limited areas on Sumatra and Celebes.	Probably associated with *Pistia* as well as other aquatic plants.
M. indiana	Sumatra, Flores, Banka, Java, and New Guinea.	Associated with *Pistia.*
M. uniformis	Widespread from Sumatra to New Guinea.	Associated with *Pistia* and *Eichhornia.*
M. annulifera	Throughout the archipelago.	Associated with *Pistia.*
M. longipalpis	Widespread from Sumatra to the Molukkas.	Similar to *annulata.*
Anopheles barbirostris	All islands west of Wallace's line.	Ubiquitous fresh-water breeder.
A. hyrcanus sinensis	Sumatra and Java; perhaps elsewhere.	Swamps, rice fields, and other fresh-water habitats.
A. hyrcanus X	Known from S. E. Borneo, Java, and Celebes.	Primarily in swamps and rice fields.
Culex fatigans (= *quinquefasciatus*).	Throughout the archipelago.	All kinds of artificial water near dwellings.
C. vishnui	Widespread from Sumatra to New Guinea.	Lakes, rivers, small streams. drainage ditches, flooded grassland, irrigation water, lagoons, etc.
A. punctulatus moluccensis.	New Guinea, Molukkas, and adjacent islands.	All types of habitats, fresh or brackish, standing or flowing. *Sunlight is necessary.*
Anopheles punctulatus punctulatus.	New Guinea, Molukkas, and adjacent islands.	Same as *moluccensis* except that it is said not to breed in flowing water.
A. bancroftii	New Guinea; probably Molukkas and adjacent islands.	Small clear-water shady lakes with aquatic vegetation.
A. leucosphyrus hackeri.	Reported from Celebes, Borneo, Sangihe Is. and Kabaena Is.	Small bodies of water. *Shade is required.*
A. aconitus	Everywhere west of Wallace's line from 1,200–2,500 feet.	Flooded rice fields, fresh-water fish ponds, ditches, etc.

SYNOPSIS OF THE KNOWN NATURAL FILARIASIS VECTORS OF THE NETHERLANDS INDIES

Habits of adults	Species of filaria	Importance as vector	Remarks
Strongly anthropophilic. Phototropic at night.	*malayi*	A good vector	Very numerous at Dermajoe (Benkoelen, Sumatra).
Anthropophilic	*malayi*	A good vector	
Anthropophilic	*malayi*	A good vector	
Strongly anthropophilic.	*malayi*	An important vector	Most numerous of the *Mansonioides* mosquitoes
Strongly anthropophilic.	*malayi*	An important vector	
Strongly anthropophilic in Celebes; attacks man less frequently elsewhere.	*malayi*	A very important vector.	
Anthropophilic	*malayi*	? (Reported only once as a natural vector.)	A vector in China.
Anthropophilic	*malayi*	Known as a vector only at Martepoera (Borneo).	
Strictly a house mosquito. Never found far from dwellings. Anthropophilic.	*bancrofti*	An important vector. Probably not as important in Neth. Indies as other areas.	
Anthropophilic, begins biting as soon as dark.	*bancrofti*	Probably unimportant. Only one record of natural infection.	A vector in India.
Exclusively anthropophilic.	*bancrofti*	Important vector in New Guinea.	
Exclusively anthropophilic. No "hum" as it attacks.	*bancrofti* *bancrofti*	Probably a vector in New Guinea.	
Anthropophilic	*bancrofti*	A vector in New Guinea.	
Anthropophilic and zoophilic.	*bancrofti*	? (Reported only once as natural vector.)	
Probably more zoophilic than anthropophilic.	*bancrofti*	? (Reported only once as natural vector.)	

See following page for list of probable and doubtful vectors of filariae in the Netherlands Indies.

List of Probable and Doubtful Vectors of Filariae in the Netherlands Indies

The following have been infected experimentally with *bancrofti* (with development of infective larvae) in the Netherlands Indies:

Anopheles sundaicus
A. subpictus
A. annularis
A. barbirostris
A. vagus
A. tessellatus
A. maculatus (?)
Culex fuscocephalus
C. whitmorei
C. annulirostris
C. bitaeniorhynchus (?)
C. tritaeniorhynchus (?)
C. sitiens (?)

The following which occur in the Netherlands Indies have been reported as *bancrofti* vectors elsewhere:

Anopheles amictus (Australia)
A. hyrcanus nigerrimus (Malaya)
A. philippinensis (India)
A. pallidus (India)
Aëdes scutellaris (Fiji Islands)
A. vigilax (Australia)

Chapter IV

DENGUE

Dengue is endemic throughout the Netherlands Indies although it has not occurred in epidemic proportions since 1901. The dengue-like fever described by van der Scheer from Batavia and now known as the *five-day fever of van der Scheer* has the same symptomology as dengue and differs from it only in the duration of the fever. It is also known as endemic dengue. According to de Langen (1936) it is widespread over the East Indies and should not be differentiated from other dengue-like fevers of different duration. In Batavia there are cases of dengue-like fever varying in duration from 2 to 10 days. Furthermore Snijders and Binger fed *Aëdes aegypti* and *Aëdes albopictus* on endemic cases of dengue in Medan (Sumatra) and sent them to the Colonial Institute in Amsterdam where they were refed on volunteers. All of the volunteers developed dengue but it was shown that the same virus produced different types of fevers in different individuals.

The typical endemic dengue of the Netherlands Indies is characterized by de Langen (1936) as a disease with a sudden onset of fever with chills and shivers. The face is red and swollen and the conjunctivae infected. The fever shows definitely a remittent character. Often three stages are recognized: (1) Original rise in temperature to 102° to 104° F. (2) Remission followed by intermittent attacks of 99.3° to 101.3° F. (3) A rise in fever on the next to the last day in which the temperature may become as high as in the original attack. Following this the tem-

perature returns to normal on the next day. Newcomers to the region are particularly susceptible.

According to Bonne-Wepster and Brug (1937) the vectors of dengue in the Netherlands Indies are *Aëdes aegypti* and *albopictus*. Mertens has shown that *aegypti* is a better vector than *albopictus*.

Aëdes aegypti is world-wide in its distribution between 40° N. and 40° S. latitude. More is known of the habits of this species than of any other mosquito. Its habits are no different in the Netherlands Indies than elsewhere. Larvae can be found in all types of artificial accumulations even in minute volumes. Typical breeding places are rain barrels, tanks, cisterns, tin cans, urns, as well as water accumulated on leaves and in plant axils. It is almost exclusively a house mosquito and is rarely found more than 1,500 feet from dwellings. It is strongly anthropophilic. The younger adults are daytime fliers until a meal of blood is secured and thereafter nocturnal. It is said to prefer the blood of white races to that of the dark races.

In the Netherlands Indies there are definite records of its occurrence on Sumatra, Poeloeh Weh, Billiton, Bangka, Anambas Islands, Java, Edam, Karimendjowo (Kariman Djawa), Borneo, Tarakan Island, Kleine Paternoster Islands, Poeloeh Laoet, Celebes, Buton (Boetoeng), Soembawa, Flores, Alor, Timor, Tanimbar Islands, Halmahera, Ternate, Ceram, Ambon, Saparoea, Banda, and New Guinea (fig. 8, p. 78). It doubtlessly occurs on other islands also.

Aëdes albopictus is a common mosquito. It was shown to be a vector in the Netherlands Indies by Schüffner and Snijder (1931). It breeds near dwellings in habitats similar to those of *aegypti*. Larvae are found in water tanks, tin cans, cisterns, plant axils, rain barrels, etc., but rarely in ponds, ditches, and mud puddles. It

FIG. 8 Distribution of Dengue Vectors in the Netherlands Indies

is strongly anthropophilic and its bite is more irritating than that of *aegypti*. It is widely distributed throughout the Netherlands Indies with definite records from Sumatra, Poeloeh Weh, Simaloer, Siboroet, Nias, Mentawei Islands, Doerian, Billiton, Java, Karimendjowo (Kariman Djawa), Borneo, Tarakan Island, Kleine Paternoster Islands, Celebes, Buton, Kabaena, Bali, Lombok, Soemba, Flores, Alor, Timor, Ceram, Ambon, Saparoea, and New Guinea (fig. 8).

Chapter V

OTHER INSECT-BORNE DISEASES

Yellow Fever

Yellow fever has never been reported from the Netherlands Indies and is assumed to be nonexistent there. However *Aëdes albopictus* and *aegypti* which are good vectors of yellow fever in other parts of the world are common mosquitoes throughout the archipelago. Brug (1938) points out that the introduction of yellow fever into the Netherlands Indies with these vectors so widespread and numerous and with the nonimmune native population might be extremely tragic. The Netherlands Indies Public Health Service has been extremely vigilant in preventing the importation of any yellow fever cases or cases of suspected yellow fever. Furthermore a statute, with severe penalty, forbids the importation of yellow fever virus even for scientific research.

De Langen and Lichtenstein (1936) point out the interesting fact that the monkeys of the Netherlands Indies possess a fair degree of immunity to yellow fever when compared with the immunity in the same species elsewhere. Whether this is the immunity acquired from infection by a closely related virus is a matter of sheer speculation. There is no information on the resistence or immunity of the Netherlands Indies population to yellow fever. It is therefore only safe to assume that introduction of yellow fever would result in its becoming widespread. This should be considered as a distinct possibility in view of rapid wartime transportation which could result

in the introduction of either human cases or infected mosquitoes. Furthermore, it must be assumed that the rigid quarantine procedures of the Dutch have probably broken down thereby increasing the hazard of importation. There is also even the remote possibility of its use by the enemy as a combat weapon.

Arthropod-borne Diseases (Other Than Yellow Fever) Which Do Not Occur in the Netherlands Indies

Sleeping sickness has never been reported. This is because the genus *Glossina* does not occur. Although *Triatoma rubrofasciata* is common in the Netherlands Indies it apparently is not a host to any pathogenic trypanosomes which probably accounts for the absence of **Chagas' disease.** Also there have been no autochthonous cases of **kala-azar.** Whether or not **kala-azar** can become established in the archipelago is difficult to say until there is more definite information on its transmission. All cases of **dracontiasis** prove to be imported in spite of the fact that the *Cyclops* of the Netherlands Indies can be easily infected with the larvae of *Dracunculus*. Brug (1938) suggests that the absence of *Loa loa* and *Onchocerca* infections can be attributed to the relatively small numbers of *Chrysops* and *Simulium*. There are no authentic records of any cases of **tick-borne fevers. Relapsing fever** has been confined to a few imported Chinese cases. Brug (1938) believes that this is because of the absence of the body louse due to the scanty clothing worn by the natives. There are no authentic records of **louse-borne typhus.**

Chapter VI

RICKETTSIOSES

There has been much confusion in the literature concerning the rickettsial infections of the Netherlands Indies. Recently Kouwenaar (1941), who has done much work on rickettsioses in the Netherlands Indies, has presented ample evidence to prove that in reality only two diseases due to *Rickettsia* exist here. These are:

1. **Sumatran mite fever** and **Malayan scrub typhus,** the same disease with different clinical manifestations; probably the same as Malayan tsutsugamushi and kedani.

2. **Shop typhus,** doubtlessly identical with endemic murine typhus.

These two rickettsioses can be differentiated with the Weil-Felix agglutination reaction using *B. proteus* strains, OX–19 and OX–K. Although these strains probably have no relation to the diseases or to the *Rickettsia* which cause them they are agglutinated characteristically by the serum of infected individuals.

	Shop typhus	Sumatran mite fever, Malayan scrub typhus
OX–19	+ + +	–
OX–K	–	+ + +

Table 7 contains a tabulation of some of the names used in describing these diseases in the Netherlands Indies.

TABLE 7.—*Rickettsioses of the Netherlands Indies: Tabulation of some synonymous terms*

Mite fever-scrub typhus (OX–K)	*Murine Typhus (OX–19)*
(a) *With primary lesion*	
mijte koorts	shop typhus
mite fever	urban typhus
Sumatran mite fever	**tropical typhus
pseudotyphus of Sumatra	
pseudotyphus of Deli	
*tsutsugamushi (of Malaya)	
*kedani (of Malaya)	
(b) *Without primary lesion*	
scrub typhus	
rural typhus	
**tropical typhus	

* It is suggested that the mite fever-scrub typhus of Sumatra and Java because of its lower case mortality is somewhat different than the Japanese tsutsugamushi.

** Because of the absence of the primary lesion scrub typhus and shop typhus were formerly grouped together (as tropical typhus).

"Pseudotyphus" as used by Schüffner (1908) included cases with and without the primary lesion and is therefore analogous with the modern concept of the identity of scrub typhus and mite fever.

Sumatran Mite Fever—Malayan Scrub Typhus

Mite fever and scrub typhus were formerly distinguished from each other because of the development of a primary lesion and swelling of lymph glands in the former and the absence of these symptoms in the latter. However it is interesting that Schüffner (1908) who first described the disease in Sumatra as "pseudotyphus" did not make this distinction but regarded all cases as "pseudotyphus" regardless of presence or absence of a primary lesion. The identical Weil-Felix reaction to OX–K and the identical epidemiology of the two have led Kouwenaar (1941) to conclude that they represent merely different clinical manifestations of the same disease. The exact relation with tsutsugamushi and kedani is not certain although they are obviously similar if not identical. Kouwenaar (1941) feels that mite fever-scrub typhus is the same as tsutsugamushi of Malaya but that it is a milder disease than that of Japan and Formosa. In support of this he cites the 20 percent

case mortality of Japanese tsutsugamushi as compared to 5 percent or less in Sumatra. Also he states that there is less leukopenia in Sumatran cases than in Japanese tsutsugamushi.

Kouwenaar (1940) described the pathology of scrub typhus and mite fever. In an extensive review of the rickettsioses of the Netherlands Indies (1941) he describes his clinical observations on mite fever and scrub typhus as follows (in translation):

In mite fever a primary ulcer develops in the area of the mite bite. The primary ulcer is most likely to appear where the skin is thin, such as in the skin folds on the neck, in the axillary or genital regions. The ulcer consists of a skin necrosis, 5 to 10 mm. in diameter around the bite; occasionally there may be two or more of these ulcers. The ulcer is red at first but is seldom observed in this state. Its appearance is very characteristic and once observed will always be remembered. The skin then reddens and large red or red-brown macules or exanthematous maculopapules develop which seldom unite before the end of the first week. These macules or exanthematous maculopapules are most numerous and obvious on the extremities and on the trunk. The lymph nodes in the region of the primary ulcer become swollen and sometimes painful. Those further away are not affected. The pulse early in the course of the disease is somewhat retarded and full. In severe cases the rate increases slightly and the beat becomes progressively weaker and sometimes irregular. If the pulse rate becomes higher than 120 beats a minute, prognosis is bad. Enlargement of the heart is infrequent. Some cases become cyanotic; sometimes there is myocarditis; pericarditis is rare. Infrequently gangrene develops in the extremities. Vomiting, diarrhea, obstipation, meteorism, or occasional intestinal hemorrhages may occur. Frequently there is bronchitis and in all fatal cases, pneumonia. The spleen enlarges and the liver is usually swollen, smooth and soft and not painful. There are headaches, insomnia and infrequently coma and delirium. There may be infections of the conjunctiva. The patient may become hard of hearing which accompanies encephalitis. A slight leukocytosis develops and infrequently (10 to 20 percent of the cases) leukopenia. In the second or third week a lymphocytosis develops. Eosinophils decrease in number but usually do not disappear. The urine gives a strong positive diazo as well as a urobilin reaction. Usually there is febrile albuminuria with leukocytes and epithelial elements in the sediment. Bacteriological investigations give positive results. Weil-Felix is positive to OX–K. A weak agglutination occurs in many cases.

It is only when the titer reaches a strength of 1/250 or higher that a positive diagnosis can be made on this basis. In addition to the strength of the titer there should be a gradual increase during the course of the disease.

Case mortality in scrub typhus and mite fever is about 5 percent among Europeans and higher among the natives. Death is usually due to circulatory inadequacy along with the development of pneumonia. Death may come after the fever has subsided. Tachycardia, spasms, and palpitations may persist for months after recovery. Recovery is usually slow. The immunity acquired from infection is of short duration.

Differential Diagnosis.—Mite fever and scrub typhus as they are now recognized differ from each other only in the fact that mite fever develops a primary ulcer. These can be differentiated from classical typhus by the Weil-Felix reaction. As yet the therapy of scrub typhus and mite fever is purely symptomatic. No specific drug is known. Prophylaxis consists of avoiding mites and possibly ticks. Immunity is brief. As yet there is no good prophylactic vaccine.

The epidemiology of mite fever and scrub typhus presents a very interesting picture. Their identical epidemiology has been described by Kouwenaar and Wolff (1936). Cases are confined exclusively to plantation workers, soldiers, hunters and others who work in the jungle grass or bush especially where the jungle reed, *Imperata cylindrica*, is abundant. Walch (1923) and Walch and Keukenschrijver (1923) have concluded, largely on epidemiological observations, that the vectors are the hexapod larvae of trombiculid mites. Their infection experiments are not entirely conclusive. Previously Japanese workers had incriminated, also largely on epidemiological data, the larva of *Trombicula akamushi* as the vector of tsutsugamushi. Heaslip (1941) believes the *T. deliensis* larva to be the vector of tsutsugamushi in Queensland. However he rightly points out the fact that the evidence concerning the trombiculid larvae as vectors is still largely circumstantial and that ticks have not definitely been eliminated as possible vectors. Some Dutch physicians have thought that perhaps the vector in scrub typhus was a tick whereas the vector in mite

fever was a mite thereby accounting for the presence and absence of the primary lesion. However there is no evidence in the literature to support this.

Walch and Keukenschrijver (1923) concluded that the *deliensis* larva was the important vector and that the *schüffneri* larva was of secondary importance. The tendency now appears not to regard *schüffneri* as a vector (de Langen and Lichtenstein, 1936).

Epidemics are usually characterized by a rather high percentage of cases in exposed groups. Schüffner and Wachsmuth (1909) described epidemics in which there were 158 cases in a group of 7,700 and 53 in a group of 900. Walch and Keukenschrijver (1923) described 111 cases in a group of 250 coolies engaged in clearing operations in East Sumatra. A typical epidemic is that described by van der Schweff (1941) in Atjeh (Sumatra) where clearing was undertaken for a new agricultural development. Twenty-nine cases of mite fever (with primary lesion) and 48 cases of scrub typhus (no primary lesion) were recorded among those working in the jungle grass.

Plantation physicians in Sumatra recommend the use of a mixture of 0.8 parts of cajeput oil and 18 parts of coconut oil as a repellent against mites. It is stated that it keeps down the incidence of mite fever and scrub typhus.

Scrub typhus and mite fever have been most prevalent in Sumatra, especially on the plantations in Atjeh and East Sumatra in the region of Deli. A very small number of cases have been reported from Java by Wolff and de Graaf (1939) and in the reports in the *Mededeeling van den Dienst der Volksgezondheid*. Bessem (1935) reported a case from Borneo. Kouwenaar (1941) speaks of a disease in Celebes, without reference to its prevalence, which he describes as intermediate between Japanese tsutsugamushi and the Sumatran disease. Mite fever has not been reported from Dutch New Guinea. However

Heaslip (1941) describes a tsutsugamushi from Queensland and it has also been reported from Australian New Guinea. Hence the occurrence of a mite fever in Dutch New Guinea is a probability.

Vectors of Mite Fever and Scrub Typhus

It is reasonably certain that vectors of mite fever and scrub typhus are the hexapod larvae of certain trombiculid mites. As mentioned previously, Walch and Keukenschrijver (1923) believed that the *Trombicula deliensis* larva was the important vector with *T. schüffneri* having a secondary role. It now appears doubtful that *schüffneri* has any role whatsoever in transmission.

Adult trombiculids are believed to feed on decaying vegetable material in loose, moist surface soil, preferably humus, where there is undisturbed wild vegetation. Eggs are deposited on the ground during the summer and autumn. The hexapod larvae soon emerge and attach themselves to various mammalian and avian hosts. When they become engorged with blood they drop off the host and make their way into the soil where, following a quiescent stage, they metamorphose into nymphs or adults. It is believed that the larvae do not change hosts. If this is true it means that the *Rickettsia* are probably carried from generation to generation through the ova of the mites.

The larvae of the trombiculid mites are very minute, barely perceptible to the human eye. They are usually bright yellow, orange, or red. Like all other acarid larvae they have six legs and no antennae.

The taxonomy of the genus *Trombicula* is muddled because many of the species are known only as larvae. Several species are described from the Netherlands Indies. The *T. deliensis* larva, which has been reported from Java, Sumatra, and Malaya is orange-red to yellow. It is

common on rats of various species in Sumatra. Walch and Keukenschrijver (1923) found it on two species of cuckoo-like birds, *Centropus javonicus* and *Rhinorthra chlorophaea.* It is possible that they are important in its dispersal. *T. deliensis* is probably the only vector of mite fever and scrub typhus although this has not been definitely established.

The larva of *T. schüffneri* is red. It is common in Sumatra. Regarded by Walch and Keukenschrijver (1923) as a vector this now seems to be doubtful (de Langen and Lichtenstein, 1936). The *T. pseudo-akamushi* larva is bright red. These larvae are ubiquitous in Sumatra on many birds and mammals. The larva of *T. oudemansi* is yellowish-white and is common on the rats and mice of Java and Sumatra. The larvae of *T. acuscutellaris* and *densipiliata* have both been reported from Sumatra. Both are red. The former is said to occur commonly on rats. *T. rara* larvae have also been reported from Sumatra. *T. wichmanni* larvae are the "gonones" of Celebes. They are primarily parasites of the Crown Pigeon (*Goura* sp.) but also attack man. On New Guinea the larvae of *T. vandersandei* also parasitize man and are known as "gonones." A complete tabulation of the trombiculid larvae reported from the Netherlands Indies is recorded in the section on Animals of Medical Importance. It is important to note that the *deliensis* larva, the vector of mite fever, is the only orange-red to yellow larva found thus far on man. A table of morphological details to aid in identification is given in Appendix F.

Shop Typhus

According to Kouwenaar (1941) it has never been conclusively proved that shop typhus is the same disease as endemic murine typhus. Nevertheless he points out that there can be little doubt of it because the Weil-Felix

reaction as well as the epidemiology of shop typhus and endemic murine typhus are identical. As yet no arthropod vector has been definitely incriminated. However it is assumed that the vector is the rat flea, *Xenopsylla cheopis*, although there is the possibility of other fleas being involved also.

Shop typhus is primarily a disease of the larger cities although there are, according to Kouwenaar (1941), a few cases recorded from plantations. It is not an important disease in the Netherlands Indies.

Louse-borne typhus is not known to occur.

Chapter VII

PLAGUE AND LEPTOSPIROSIS

Plague

In recent years plague has occurred only in Java where it was first recorded in 1911. The last record of an epidemic in the Netherlands Indies outside of Java was in Makassar in 1922. The last epidemic in Sumatra was in 1920 at Palembang. The epidemics at Makassar and Palembang were both of short duration. However in Java the disease is enzootic in the rat population in which it occasionally reaches epizootic proportions. In the regions of Java where housing is of such nature that the natives come into intimate contact with the rats, the rat plague epizootics are reflected as epidemics of human plague.

The papers of Otten who has developed a live bacillus plague vaccine, and of Rosier, who has been charged with the plague control program, are the best sources of information on plague in the Netherlands Indies.

An idea of the importance of plague in Java may be obtained from a tabulation (table 8) of the recorded cases as given by Rosier (1941).

Plague was originally most prevalent in East Java. However in recent years the great majority of the cases have been reported from West Java. Rosier (1938) listed the following as plague regions: Malang (East Java), Djokjakarta (Central Java), Prahoe (Central Java), Slamet (Central Java), Pekalongan (northern Central Java), a

large area in West Java including Priangan, Cheribon, Tjiremai, Tjikoerao, and Tangkoebanprahoe.

TABLE 8.—*Reported cases of plague in the Netherlands Indies*

Year	East Java	Central Java	West Java	Total
1911	2,155	1	1	2,157
1912	2,276	1	1	2,278
1913	11,384	2	1	11,387
1914	15,751	5	1	15,757
1915	4,831	1,406	1	6,238
1916	596	592	1	1,189
1917	202	219	1	422
1918	221	513	1	735
1919	196	2,785	1	2,982
1920	248	8,891	13	9,152
1921	257	9,501	5	9,763
1922	137	10,819	1	10,957
1923	73	8,323	271	8,667
1924	157	12,547	349	13,053
1925	260	12,969	1,275	14,504
1926	71	6,829	871	7,771
1927	219	6,364	1,172	7,755
1928	35	3,741	824	4,600
1929	73	2,210	1,812	4,095
1930	3	3,282	1,695	4,512
1931	30	3,031	1,478	4,539
1932	5	2,071	4,366	6,442
1933	8	1,685	15,188	16,881
1934	2	2,668	20,569	23,239
1935	1	2,687	10,307	12,995
1936	4	1,693	4,490	6,187
1937	44	1,156	2,614	3,814
1938	20	616	1,447	2,083
1939	15	403	1,123	1,541

Plague in Java is now primarily a disease of the highlands above 1,500 feet where the climate is humid and subtropical. This is probably due in part to the "better housing" program which has eliminated rats from dwellings in many parts of the island and in part to the fact that *Xenopsylla cheopis* tends to be more prevalent at higher altitudes.

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All age groups and races are affected uniformly. There are no sex differences. Generally the maximum number of cases occurs at the beginning of the rainy season (December-January), whereas there is a remission during the dry monsoon (July–August). About 8 to 10 percent of the cases are pneumonic; these frequently occur in family groups. The case fatality in the bubonic type is 60 to 70 percent; in septicaemic about 90 percent; and in pneumonic, about 100 percent.

The biology, distribution, and ecology of the rats of Java as well as their role in plague has been thoroughly studied and discussed by Kopstein (1931). The principal rodent reservoir is the Malayan gray-bellied house rat, *Rattus rattus diardii*. In the mountains when this species dies in sufficient numbers, it may be replaced in dwellings by the lesser Malayan bush rat, *R. r. ephippium*, normally an outdoor species. The Norway rat, *R. r. norvegicus*, and the lesser Malay house rat *R. r. concolor*, may also enter dwellings in the absence of *diardii* particularly in the lower country. The rice-field rat, *R. r. argentiventer*, may also enter houses when there is no *diardii* and then can be important in transmitting plague. Infected rats are transported from place to place in rice shipments. *Xenopsylla cheopis* is the important flea vector. In general it is thought that *X. astia* and *Pygiopsylla ahalae* (=*Stivialis cognatus*) are of minor importance as vectors. The Dutch do not regard *Pulex irritans* as a vector.

The control measures employed by the Dutch have been (1) isolation of pneumonic cases, (2) ship quarantine, (3) vaccination, and (4) housing improvement.

Housing improvement has been subsidized by the government. Since 1911 more than a million and a half dwellings have been improved or rebuilt. As a result the house rat population in many areas has been substantially reduced or eliminated.

Vaccination has been almost exclusively with the live bacillus vaccine developed by Otten (1930–1940). He has summarized his work in an extensive paper (1941) which describes both the production and use of the live vaccine.

The live plague vaccine was first shown by Otten to be effective in controlled vaccination in which families were partially vaccinated i. e., within each family some were vaccinated and some were left as unvaccinated controls. When this showed favorable results the vaccine was used on a large scale. Mass vaccinations were begun in 1935 in the midst of a severe epidemic. In order to have reliable information on its effectiveness tabulations were made of the numbers of cases among vaccinated and nonvaccinated groups. From the number of cases in the nonvaccinated group Otten calculated the number of cases that would have occurred had no vaccinations been made. In this way it was possible to show the effectiveness of the vaccination program. His calculations are as follows:

Year	Percent population vaccinated	Plague deaths		Reduction due to vaccination
		Actual	Calculated	
1935	90	1,310	5,200	75%
1936	85	1,729	5,800	70%
1937	85	985	5,700	83%
1938	80	454	4,000	89%
1939	80	489	5,000	90%
1940	80	115	3,000	96%

Otten (1941) concludes on the basis of these data that the live vaccine is effective in controlling plague. He states that in 5 years' control more than 2,500,000 people received a total of more than 10,000,000 vaccinations and revaccinations without any harmful effects.

It is difficult to speculate on the effect that the invasion may have on the plague situation in Java. Previously epidemics have occurred at approximately 10-year intervals (1913–14, 1922–26, and 1933–35). Whether or not this is ample basis to assume the occurrence of another in 1943–1945, cannot, of course, be ascertained. Furthermore there is no way of knowing whether or not the vaccination program of 1935–40 could prevent a reoccurrence of a human plague epidemic in 1943–45 assuming that vaccination has been discontinued. It is possible that it may break out in the nonvaccinated areas. Finally there is the possibility of the reappearance of plague on Sumatra and Celebes where it has been recorded in the past; the likelihood of this is increased if the rigid Dutch quarantine regulation has broken down.

Rats in Relation to Plague.

Probably all rats are susceptible to plague. However it is those species which enter dwellings that are important from the standpoint of epidemiology. The important species to consider in Java, the only island where plague has occurred in recent years, are *Rattus rattus diardii*, *norvegicus* (local in distribution), *concolor*, *argentiventer*, and *ephippium*. *R. r. roquei* is a wild rat and may be of importance as a reservoir from which other rats become infected. (See Synopsis, p. 96.)

There has been much confusion concerning the taxonomic relationships and nomenclature of the rats of Java. In order to avoid as much of this confusion as possible a compilation of synonyms has been made. The nomenclature is that employed in the *Notes on Tropical and Exotic Diseases of Naval Importance*, Naval Medical School, 1943 (table 9).

TABLE 9.—*Synonyms. Rats of Java.*

Accepted nomenclature*	Nomenclature of Otten	Other names
Rattus rattus diardii	*Mus rattus grisiventer*	
Rattus rattus argentiventer	*Mus rattus diardii*	*Rattus rattus brevicaudatus* (of Kopstein).
Rattus rattus norvegicus	*Mus norvegicus*	*Rattus rattus decumanus.* *Rattus norvegicus.*
Rattus rattus roquei	*Mus rattus rufescens*	
Rattus rattus concolor	*Mus concolor* ("harbor *concolor*")	*R. concolor otteni* (of Kopstein).
Rattus rattus ephippium	*Mus concolor* ("mountain *concolor*")	

*Notes on Tropical and Exotic Diseases of Naval Importance. U. S. Naval Medical School, National Naval Medical Center, 1943.

R. r. diardii occurs on Java, Sumatra, and all of the Lesser Soenda Islands. The house rat of Celebes is *mindanensis*. *R. r. frugivorus* is established on Ceram, Soemba, Babar, and Moa. *R. r. argentiventer* occurs on Java, Sumatra, Borneo, Molukkas, and the Lesser Soenda Islands; *raveni* is found in Celebes, *wichmanni* on Flores, and *vitiensis* on New Guinea. Chinese junks and other native vessels of this area have a characteristic rat fauna which may be oriental in origin. It is suggested that the keys in Ernest Schwartz, *Identification of Domestic Rats of Medical Importance* (*Notes on Tropical and Exotic Diseases of Naval Importance*), Naval Medical School, 1943, be used for identification and general information on rats of this area.

SYNOPSIS OF THE RATS OF JAVA IN RELATION TO PLAGUE

Species	Body length	Tail	Color	Foot	Mammae	Habits
Rattus rattus diardii (Malayan gray-bellied house rat).	140–190 mm.	Longer than body and head.	Cinnamon above, slaty or tawny beneath.	Mean 34 mm.	2/3	The important reservoir of plague because of intimate contact with man.
Rattus rattus norvegicus (sewer rat or Norway rat).	160–250 mm.	Shorter than body and head.	Brownish gray (rarely black) above, whitish gray beneath always with white underfur.	Mean 40–62 mm. Max. 46 mm.	3/3	A port rat. Local in distribution. Records from Batavia, Ladjamajoe, Cheribon, Pekalongan, Semarang, Soerabaja, Parsavean, Vedin, Tulangagoeng, Probollingo, Banjoewangi.
Rattus rattus argentiventer (rice-field rat).	140–190 mm.	Slightly shorter than body and head.	Brownish grey white beneath.	Mean 34 mm. Max. 36 mm.	3/3	A rice-field rat. Will enter homes when *diardii* dies off.
Rattus rattus concolor (Lesser Malay house rat).	110–140 mm.	Longer than body and head.	Dark brown above bluish gray beneath.	Mean 21 mm. Max. 25 mm.	2/2	It may invade houses when the other species die off. Occurs only in North Java.
Rattus rattus ephippium (Lesser Malay bush rat).	110–125 mm.	Slightly longer than body and head.	Brown above buffy below.	24–26 mm.	2/2	A small rat. Primarily a bush rat in the higher country. May enter dwellings.
Rattus rattus roquei (common tree rat).	140–150 mm.	Longer than body and head.	Cinnamon above white or buff on belly. No dark underfur.	About 34 mm.	2/3	The wild rat. Very occasionally enters dwellings. May serve as reservoir for plague.

Leptospirosis

Leptospirosis is more prevalent in the Netherlands Indies than in other parts of the world. The best sources of information are the papers of Esseveld, Collier, Mochtar and their co-workers (1937–41). In general, leptospiral infections in the Netherlands Indies are mild; fatal cases are rare and jaundice is observed in only about 10 percent of the cases. The actual number of cases reported is small. For instance Sardjito (1938) points out that only 3 cases were reported in Batavia in 8 years and that only 9 cases were reported in Semarang in a single year. However, because of the mild nature of the disease it can well be assumed that the majority of the cases never come to medical attention. Recent reports from hospitals in Sumatra indicate that many cases formerly diagnosed as influenza (colds with fever) are in reality leptospiroses.

The bulk of the cases of leptospirosis have been observed in the Asahan area of the east coast of Sumatra where the mortality is higher than elsewhere. Mochtar and Esseveld (1939) compiled information on the known incidence of leptospirosis for the entire archipelago. They record epidemics and cases from the Deli Valley (1922); Bangkinang Central Sumatra (1928–30); Makassar; Tarakan Island near Borneo; Singkawan, West Borneo; Banka; Billiton; and Java. They state that leptospirosis occurs throughout Sumatra and that "some cases," including Weil's disease, have been observed on Java. A special focus of leptospirosis occurs on the Island of Noesakambangan opposite the city of Tjilatjap on the south coast of Central Java.

A great deal of attention has been given to the isolation of leptospirae. From 1932–38 Walch-Sorgdrager, Bolamder, Schüffner, and Wolff (1940) state that 426 strains of leptospirae were isolated. According to Mochtar and

Esseveld (1939) only four different strains have been isolated from human cases. The Rachmat type which is probably the same as the Japanese *L. autumnalis* (=*akiyani*) has been reported from human cases in Java and Sumatra. The *Salinem* type is similar to *L. icterohaemorrhagiae* but serologically distinguishable from it. It also has been found in human cases in Sumatra and Java. *L. bataviae* has the widest geographical distribution having been reported from human cases in Java, Sumatra, Borneo, Bangka, Billiton, Tarakan, and Celebes. *L. icterohaemorrhagiae* has been reported in humans from Java only. In addition to these four types recorded by Mochtar and Esseveld (1939), Sardjito (1940) has reported 2 cases of human leptospirosis in Central Java from which he isolated type 2 R 173. A very few human cases due to *L. hebdomadis* and several unknown strains (*L. djasiman*, *L. naäm*, *L. sarmin*) have been found.

On Noesakambangan in 1940 there were 12 Rachmat cases, 17 *bataviae* cases, and 5 *icterohaemorrhagiae* cases. This variety may be due to the fact that the island has 4,000 to 7,000 chain gang prisoners from all parts of the archipelago.

Considerable attention has also been given to the reservoir hosts of leptospirosis. Sardjito, Mochtar, and Wirasmo (1937) showed that *R. r. argentiventer*, the ricefield rat, can harbor several strains pathogenic to guinea pigs and possibly pathogenic to man. They regard *R. r. norvegicus* as a normal reservoir of *icterohaemorrhagiae*. In Makassar *R. r. norvegicus* was found with *javanica*. *R. r. argentiventer* has also been found to harbor *javanica*, which is practically nonpathogenic. Most investigators regard the Norway rat as the most dangerous reservoir in Java. In Batavia about 50 percent are infected with leptospirae, mostly with the *bataviae* type. *L. hebdomadis* has been found in dogs in Sumatra. Cats have been found

infected with *bataviae*, *javanica*, and *icterohaemorrhagiae*. Dogs in Batavia have been found with *bataviae* whereas hogs were found to harbor *pomona* which is only slightly virulent to guinea pigs and mice.

Synopsis of leptospirosis of the Netherlands Indies

	Human cases	Norway rats	Field rats	Dogs
Sumatra: Deli	*L. salinem* *L. rachmat*[1] *L. hebdomadis* (very rare).[2]	No *L. salinem* No *L. rachmat*.	*L. javanica*	*L. hebdomadis*.
Central and South Java.	*L. bataviae*.[4]			
West Java	*L. bataviae* *L. rachmat* (rare) *L. hebdomadis* (very rare). *L. pomona* (?).	*L. bataviae* *L. javanica*	*L. javanica* *L. bataviae* (very rare).	*L. bataviae*. *L. pomona*.[3]
Middle Java:				
(*a*) Semarang	*L. icterohaemorrhagiae*. *L. salinem*, *L. bataviae*, "L. R 173" } rare	*L. icterohemorrhagiae*.	*L. javanica*. *L. salinem* (very rare) "L. R 173" (very rare).	
(*b*) Mageland	*L. bataviae*. *L. icterohaemorrhagiae*.			
(*c*) Noesakambangan.	*L. rachmat*. *L. bataviae*. *L. icterohaemorrhagiae*. *L. hebdomadis*.			
Celebes	*L. bataviae*	*L. bataviae*	*L. javanica*.	
Borneo	*L. bataviae*.			
Tarakan	*L. bataviae*.			
Bangka	*L. bataviae*.			
Billiton	*L. bataviae*.			

[1] *L. rachmat* identical with *L. autumnalis* or *L. akiyani*.

[2] *L. hebdomadis*, *L. pomona* never causes jaundice.
L. hebdomadis and *L. pomona* are nonvirulent for guinea pigs.

[3] *L. pomona* has been found in hogs in West Java.

[4] *L. bataviae* has been found in adult cats.

(Prepared by Dr. I. Snapper, Surgeon General's Office, U. S. Army)

Chapter VIII

ENTERIC DISEASES

Because of improper disposal of sewage, unsanitary water supplies, unhygienic handling of food, lack of control of flies, and the generally poor hygienic conditions in the native villages, all communicable enteric diseases are prevalent.

Bacillary Dysentery

Bacillary dystentery occurs on all of the inhabited islands. There are no reliable morbidity figures because most cases do not come to medical attention. The disease is both endemic and epidemic. Table 10 summarizes the hospitalized cases of dysentery for 1935-39 (from *Indisch Verslag*, 1936-40). These figures include all cases diagnosed as dysentery.

TABLE 10.—*Dysentery, hospital admissions*

Year	Number of hospitals reporting	Total admissions	Number dysentery admissions	Percent dysentery admissions	Dysentery case fatality (percent)
1934	221	207,325	4,488	2.2	8.4
1935	185	201,597	4,355	2.2	10.4
1936	190	223,469	(*)	----------	----------
1937	176	239,163	(*)	----------	----------
1938	167	238,960	5,826	2.6	10.3
1939	176	255,552	6,391	2.5	11.5

*Dysentery cases not recorded separately.

The following reports of cases of bacillary dysentery were made to the League of Nations by the Netherlands Indies Public Health Service:

	1936	1937	1938
Java and Madoera	623	190	354
Other Islands	2, 280	7, 449	5, 813

Since 1931 the Eijkman Institute Laboratory has recorded data on types of dysentery bacillae from the dysentery cases for which it has made laboratory diagnoses. These records are summarized in table 11. About 70 percent of the cases were Flexner group (mostly Y); 13 percent were Sonne and 13 percent Shiga.

TABLE 11.—*Summary of dysentery analyses at the Eijkman Institute, Batavia**

Year	Total examinations	No agglutination	Flexner group	Sonne	Schmitz	Shiga	Total positive	Percent positive
1931	813	40	160	16	2	114	292	36.5
1932	1,547	120	260	36	9	79	384	25.6
1933	1,215	57	188	40	6	49	283	23.6
1934	1,308	57	270	60	6	42	378	29.0
1935	2,459	141	422	100	4	30	556	22.2
1936	3,579	53	501	90	3	49	643	17.9
1937	4,576	29	436	124	8	39	607	13.2
1938	4,616	45	537	88	6	45	676	14.7
1939	3,563	78	412	79	10	78	579	16.0
Total	23,676	620	3,186	573	54	525	4,398	
			73%	13%	1.2%	13%		

*Practically all of the cases were from Java.

All racial groups appear to be approximately equally susceptible to the Flexner group. There is a tendency

towards a greater incidence of Sonne among Europeans and a greater incidence of Shiga among the natives (table 12).

TABLE 12.—*Bacillary dysentery morbidity, 1931–39*

	Europeans	Percent	Chinese	Percent	Natives	Percent	Total	Percent
Flexner group	418	69.8	577	73.9	1,323	69.5	2,318	70.3
Sonne	136	22.7	92	11.6	239	12.5	467	14.2
Schmitz	6	1.0	17	2.3	26	1.2	49	1.5
Shiga	39	6.5	96	12.4	322	16.8	457	13.9
	599	100.0	782	100.2	1,910	100.0	3,291	99.9

Dinger et al. (1940) studied bacterial dysentery in a "city study unit" in Batavia. They concluded in this city, which has a sanitary water supply, that the majority of the cases were due to direct contacts. Of 149 bacteriologically analyzed cases, 112 were Flexner, 30 were Sonne, and 4 were Schmitz. Wolff (1940) studied the occurrence of Sonne dysentery on the East Coast of Sumatra from 1925 to 1936, during which time 676 cases were diagnosed bacteriologically. Only 7 percent were Sonne. The ratio of Sonne to Flexner varied from 5:100 to 13:100. Sonne infections were much more prevalent in Europeans than among the natives.

The reports of the Public Health Service in the *Mededeelingen van den Dienst der Volksgezondheid* contain some records of epidemics in recent years. There was an epidemic in Makassar in 1936 in which 68 cases were bacteriologically analyzed; 50 were Flexner, 13 were Shiga, and 2 were Sonne. There was also an epidemic with 448 cases at Tandjong Priok in Java and another in East Coast, Sumatra with 460 cases. Also in 1936, 473 cases were reported from the Molukkas, 346 from Kisar Island, and 115 from Danar Island. In 1938,

366 cases were reported from Tanjong Priok in Java and 235 cases, with 78 deaths, from Madang, also in Java; 1,900 cases were reported from the Molukkas, 472 from Menado (Celebes) and 325 from East Coast, Sumatra. There was an epidemic in Makassar in January and February 1938; of 862 cases, 600 were Shiga, 231 were Flexner, 25 were Sonne, and 6 were Schmitz.

In 1938 there was also an epidemic in Bantam (West Java) with 1,287 cases and 133 deaths. There were also, in 1938, 285 cases in Menado (Celebes) and 361 cases in Timor.

Amoebic Dysentery

According to de Langen and Lichtenstein (1936) amoebic dysentery is endemic throughout the archipelago and is transmitted by flies, direct contact, and water. They cite survey figures which indicate that 10 to 17 percent of the natives have amoebiasis. The data compiled from stool examinations by the Eijkman Institute show much lower percentages. However this may be due in part to the selectivity in sampling since examinations by the Eijkman Institute would be of Europeans in a considerable degree (table 13).

TABLE 13.—*Intestinal protozoa, examinations at the Eijkman Institute*

	Percent			
	1936	1937	1938	1939
Endamoeba histolytica (vegetative and cysts)	2.1	2.3	3.5	3.5
E. coli (vegetative and cysts)	4.7	7.9	9.1	10.2
Endolimax nana (vegetative and cysts)	.4	—	.2	3.5
Iodamoeba williamsi	.6	.1	.2	3.9
Trichomonas intestinalis	1.4	1.6	3.0	1.2
Lamblia intestinalis	1.1	.5	2.1	4.7
Chilomastix mesnili	—	.1	—	—
Balantidium minutum	—	.1	—	—
Isospora hominis	—	.1	—	—
Number examined	853	751	430	250

Other Intestinal Protozoa

Table 13 shows in general the intestinal protozoa known to occur in man in the Netherlands Indies. In addition to those tabulated there have also been records of *Balantidium coli*, although it is uncommon in man. It must again be pointed out that the data in table 13 are from a selected group in Java and are not typical for the native population.

Typhoid Fever

Because of the unhygienic condition of the native villages and the unsanitary methods of fecal disposition typhoid fever is prevalent. No reliable general morbidity figures are available. The number of hospital admissions (1934–1939) for typhoid fever (and paratyphoid) are tabulated in table 14. These data are largely from Java.

TABLE 14.—*Typhoid fever, hospital admissions*

Year	Number of hospitals reporting	Total admissions	Number of admissions	Percent of total admissions	Case fatality, percent
1934 [1]	221	207,325	2,284	1.1	17.5
1935 [1]	185	201,597	2,959	1.5	18.4
1936 [2]	190	223,469	3,713	1.7	16.9
1937 [2]	176	239,163	3,904	1.6	18.0
1938 [2]	167	238,960	4,158	1.7	12.7
1939 [2]	176	255,552	3,727	1.5	18.1

[1] Typhoid fever only. [2] Typhoid and paratyphoid.

The following reports of typhoid cases were made by the Public Health Service to the League of Nations:

	1934	1935	1936	1937	1938
Java and Madoera	2,688	3,390	4,235	4,468	4,625
Other islands	107	491	488	549	672

Naturally these statistics are entirely fragmentary.

Surface waters in the more densely populated islands invariably are severely contaminated with intestinal organisms. This is verified by the investigations of Schaeffer (1940), Mom (1940), Dinger (1937), and Dinger et al. (1939). In general the sewage of the Netherlands Indies cities, according to Mom (1940) and Schaeffer (1941), has a much higher concentration of bacteria than the sewage of European cities. Dinger et al. (1939) found 0.2 percent of the population of Batavia to be typhoid carriers. These authors feel that the natives of Java possess a certain degree of immunity to typhoid perhaps because of constant exposure through their water supplies. This is not true of children. Dinger et al. (1939) regard typhoid fever as a "sporadic endemic disease with a considerably higher incidence in the younger age groups." These authors also feel that the heavy pollution of the surface waters with intestinal organisms explains the high degree of typhoid immunity which the natives appear to possess. They consider food contamination, flies, and direct contact as more important in the spread of the disease among the natives. However, for nonimmune white populations water supply in the Netherlands Indies is always a potential source of typhoid infection. In general typhoid fever in Java is nonseasonal although Dinger (1938) has shown that there is a slight correlation between rainfall and typhoid incidence which he states is perhaps due to the abundance of flies.

Excerpts from the Reports of the Public Health Service (*Jaarsverslag Dienst der Volksgezondheid in Nederlandsch-Indië*) and of the Eijkman Institute give some idea of the occurrence of typhoid fever in recent years. In 1936 Batavia reported 572 cases, Semarang (Java) 258, and Soerabaja (Java) 379. Menado (Celebes) reported 148 cases and East Coast (Sumatra) 83. These were the

principal foci in 1936. In 1937 Batavia reported 653 cases, Semarang 450, and Soerabaja 622. Medan (Sumatra) reported 73, Makassar (Celebes) 71, and Menado 79 cases. The 1938 reports recorded 503 cases from Batavia, 329 from Semarang (Java), 646 from Soerabaja, 87 cases from Medan (Sumatra), 15 from Makassar, and 71 from Menado.

Paratyphoid Fever

Paratyphoid A is much more common than paratyphoid B. Indeed records of paratyphoid B are almost nonexistent, consisting of only five cases in Java in 1938. Recent reports by the Public Health Service give some idea as to prevalence of paratyphoid A compared with records of typhoid cases. The following data are from Java and Madoera only. Deaths are given in parenthesis.

	Typhoid	Paratyphoid A
1935	3,390 (575)	323 (3)
1936	4,325 (729)	582 (29)
1937	4,468 (752)	922 (29)
1938	4,625 (747)	708 (37)

One third of the 1937 paratyphoid cases were in Batavia (314 cases with 10 deaths). In the same year Semarang had 150 cases with seven deaths, and Soerabaja 56 with two deaths. Batavia had 149 cases and 14 deaths in 1938; Semarang reported 75 cases with two deaths while Soerabaja reported 56 cases with two deaths. Reports on paratyphoid cases from the other islands are meager. There were 24 in 1937, and 44 in 1938.

Other Salmonelloses

The status of the knowledge regarding other members of the *Salmonella* group in the Netherlands Indies does not

allow any accurate estimate of their prevalence. Considerable research has been done in the Netherlands Indies. This has been summarized by Erber (1940) who states that, up to 1940, 18 species of *Salmonella* (including *paratyphosus* A and *paratyphosus* B) have been isolated. These (excluding paratyphoid A) have been isolated from 81 studied cases. Erber's list is as follows:

Salmonella parat. A
S. parat. B (Schottmüller)
S. parat. B var. Java.
S. typhi murium
S. stanley
S. heidelberg
S. brandenburg
S. derby
S. parat. C. sub-type "East Africa"
S. cholerae suis
S. thompson
S. bareilly
S. newport
S. enteriditis
S. dublin
S. panama var.
S. anatum
S. senftenberg

Cholera

There were more than 64,000 deaths from cholera in Java and Madoera in 1910. Since then the disease has decreased steadily. Prophylactic inoculation was started in 1926. No autochthonous cases have been reported in recent years. However there is always the hazard of importation from Malaya and China.

In September and October 1937 an epidemic of a disease closely resembling cholera broke out in Southwest Celebes in some of the native villages on the coast and on nearby

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islands about 36 miles north of Makassar. This epidemic has been described in detail by de Moor (1939) as well as by others. In January, February, and March 1938 it was found also in some inland villages about 6 miles south of Makassar as well as in villages north and south of the original area of infection. Two cases also occurred in the city of Makassar.

The organism involved was probably the El Tor vibrio. The epidemic was very similar to cholera and might easily have passed as such. De Moor (1939) describes the situation as follows (in translation):

> Whereas clinically and epidemiologically the diagnosis of cholera asiatica was unquestionable, some difficulties were met with in the identification of the vibrios isolated. These vibrios appeared not to differ from the real vibrio cholerâe in the common diagnostical-bacteriological examination. Even when they were inoculated on agar with sheep's blood the culture produced only digestion of the blood and showed no trace of haemolysis, the same as the cholera vibrio. If these vibrios however were inoculated in broth with sheep's blood the culture showed haemolysis as early as within 24 hours' incubation, the same as the vibrio El Tor. So this closer investigation after Kraus' method showed immediate haemolysis, which would be absent in the real cholera vibrio. Some investigators consider it a matter of absolute fact that the cholera vibrio is not haemolytic or will at most after 48 hours' incubation show late haemylosis in bloodbroth. Other investigators doubt the absolute certainty of this fact. At first the diagnosis of the vibrios isolated was therefore taken pending. Where however in cases such as this an immediate and categorical statement is desired (or is at least hard to avoid) the scholastic conception of the incapability of vibrio cholerae to give prompt haemolytic reaction was accepted and, though reluctantly, the diagnosis of vibrio El Tor was reported. Further investigation proved this diagnosis to be the correct one.

There were about 50 reported cases with a case fatality of 65 percent.

The Dutch have studied the El Tor vibrio extensively since that time. Otten (1939) refers to the vibrio of the Celebes epidemic as to *V. celebes* and thinks that it may be slightly different from the El Tor vibrio.

Chapter IX

RESPIRATORY DISEASES

As in the information on other diseases reliable morbidity data do not exist for respiratory diseases. The best information comes from hospital reports, laboratory reports, and special investigations.

Table 15 shows the proportion of hospital admissions for respiratory infections (tuberculosis not included) from a selected group of hospitals as compared to total admission in the same hospitals.

TABLE 15.—*Respiratory diseases*, hospital admissions*

Year	Number of hospitals reporting	Total admissions	Number of respiratory admissions	Percent of total admissions	Case fatality, percent
1934	221	207,325	9,691	4.7	18.5
1935	185	201,597	11,056	5.5	18.6
1936	190	223,469	7,021	3.1	25.2
1937	176	239,163	7,743	3.2	24.7
1938	167	238,960	7,822	3.3	24.6
1939	176	255,552	9,471	3.7	22.9

*Tuberculosis not included.

Pneumonia

According to de Langen and Lichtenstein (1934) pneumonia, especially lobar pneumonia, is prevalent throughout the archipelago. In table 16 statistics on hospitalized cases of pneumonia have been compiled. These, of course, are a select group, largely from Java.

TABLE 16.—*Pneumonia, hospital admissions*

Year	Number of hospitals reporting	Total admissions	Number of pneumonia admissions	Percent of total admissions	Case fatality, percent
1934	221	207,325	4,776	2.3	32.2
1935	185	201,597	5,458	2.7	32.8
1936	190	223,469	4,739	2.1	33.2
1937	176	239,163	5,300	2.2	32.9
1938	167	238,960	5,384	2.3	32.2
1939	176	255,552	6,523	2.6	30.2

Information on the types of pneumococci isolated from cases of pneumonia has been assembled by the Netherlands Indies Public Health Service in a report to a League of Nations conference in 1937 (*National Rapport van Nederlandsch-Indië voor de Intergouvernementeele Conferentie van landen in het verre oosten voor landelijke hygiëne, 3–13 Augustus 1937*). The data from this report are tabulated in table 17.

TABLE 17.—*Pneumococcus types in pneumonia cases*

Place	Number of cases	Year	Percent of Group or Type				Number of times examined
			I	II	III	IV	
Java and Sumatra	100	1929–31	42.0	26.0	0	32.0	1
Java	83	1930–31	44.4	13.9	12.5	29.2	1
Java	341	1932–35	28.0	7.0	0	57.0	1
Java	113	1932–34	42.5	9.0	0	48.5	1
Java	64	1935	38.0	8.0	0	54.0	3
Java	62	1936	58.0	8.0	1.5	32.0	3
Netherlands Indies	807	1929–37	36.4	10.9	1.6	47.8	
	1,570		36.6	10.8	1.5	47.5	
United States [1]	5,779	?	28.4	12.2	11.9	52.5	
United States [2]	3,066	1928–35	23.6	8.3	9.7	58.4	

[1] Cecil, 1937.

[2] Bullowa, 1928–35.

Kirschner and Schijveschuurmder (1939) have compiled the statistics on lobar pneumonia from the records of the Netherlands Indies Army. These are given in table 18.

TABLE 18.—*Pneumonia in the Netherlands Indies Army*

Year	Morbidity per 1,000 soldiers		Mortality per 1,000 soldiers		Fatality per 100 cases	
	European	Non-European	European	Non-European	European	Non-European
1903–29	2.3	6.2	0.24	0.59	9.1	10.6
1930	2.0	9.5	—	.96	—	10
1931	1.7	4.6	—	.40	—	9
1932	1.7	4.3	—	.70	—	16
1933	1.5	4.7	.13	.92	8	19
1934	1.2	5.9	—	1.30	—	22
1935	.8	6.3	.13	1.13	17	18
1936	1.5	5.4	.13	1.40	8	26
1937	1.1	3.3	.20	.60	22	19
Mean	2.1	6.0	.20	.66	8.6	12.1

These are the most reliable and usable data available.

Influenza

Influenza is said to be quite prevalent. The number of hospital admissions per year for influenza is about the same as that for pneumonia. Because of differences in diagnostic nomenclature it is doubtful that any very reliable comparisons can be made with statistics of other countries. The data from Netherlands Indies hospitals for a period of 6 years are recorded in table 19.

TABLE 19.—*Influenza, hospital admissions*

Year	Number of hospitals reporting	Total admissions	Number of influenza admissions	Percent of total admissions	Case fatality, percent
1934	221	207,325	4,665	2.3	1.2
1935	185	201,597	6,502	3.2	0.8
1936	190	223,469	7,603	3.4	0.9
1937	176	239,163	8,608	3.6	1.0
1938	167	238,960	6,878	2.9	0.8
1939	176	255,552	7,344	2.9	0.9

De Rook (1938) states that influenza is fairly common in New Guinea especially on the north coast.

Spirochaetosis Bronchialis

According to de Langen and Lichtenstein (1936) this disease is fairly common. No morbidity statistics are available. It is caused by *Treponema bronchialis*. These authors state that two forms, acute and chronic, occur: "In the acute form there is a high fever, coughing of an abundance of sputum which is often sanguinopurulent." The chronic form may start independently or arise from the acute form. The chronic form is frequently confused with tuberculosis. Fever is exceptional although frequently there is weakness and anemia. Prognosis in both forms is favorable.

Tuberculosis

Again reliable statistics are not available. The largest numbers of deaths due to tuberculosis are said to occur among the Menadonese in northeastern Celebes, among the Bataks around Toba Lake (Sumatra), and among the Javanese of Central Java. For the period, 1932–1936, the mortality rate due to tuberculosis in the army was 0.6 per thousand as compared with 0.7 per thousand for lobar pneumonia and 0.5 per thousand for all other infectious diseases. The Netherlands Public Health Service estimates that 10 percent of all deaths in the archipelago are due to tuberculosis. Table 20 contains statistics on hospital admissions with tuberculosis.

Recent Public Health Service Reports (*Mededeelingen van den Dienst der Volksgezondheid in Nederlandsch-Indië*) mention specifically as areas where tuberculosis is prevalent, South Borneo, East Borneo, Central Java, East Coast (Sumatra), Atjeh (Sumatra), Lombok, Bali, Nias, Riouw, Bangka, and Celebes. In the Molukkas

tuberculosis is described as sporadic except on Saparoea where it is prevalent. According to de Rook (1938) the extent and incidence of the disease in New Guinea is unknown.

TABLE 20.—*Tuberculosis, hospital admissions*

Year	Number of hospitals reporting	Total admissions	Number of tuberculosis admissions	Percent of total admissions	Case fatality, percent
1934	221	207,325	7,547	3.6	20.4
1935	185	201,597	8,271	4.1	20.1
1936	190	223,469	8,669	3.9	19.1
1937	176	239,163	8,495	3.6	20.6
1938	167	238,960	9,409	3.9	18.8
1939	176	255,552	9,950	3.9	19.1

In recent years the Public Health Service has taken steps to combat tuberculosis. However there has not been enough time to evaluate the results. Because it has been only recently that a real consciousness of the tuberculosis problem has developed data from chest examinations and Mantoux tests are too scanty to give a reliable picture.

Diphtheria

Diphtheria is a fairly common disease throughout the archipelago. Hospital admissions for diphtheria in recent years have been recorded in table 21.

TABLE 21.—*Diphtheria, hospital admissions*

Year	Number of hospitals reporting	Total admissions	Number of diphtheria admissions	Percent of total admissions	Case fatality, percent
1936	190	223,469	272	0.1	26.5
1937	176	239,163	316	.1	22.2
1938	167	238,960	349	.1	23.8
1939	176	255,552	411	.2	21.4

Cases reported to the Public Health Service are recorded in table 22. It is difficult to estimate the percentage of cases which are actually reported. Probably it is smallest in sparsely populated areas.

TABLE 22.—*Cases of diphtheria reported to the Public Health Service*

Year	Java and Madoera		Other islands		Total		Case fatality, percent
	Cases	Deaths	Cases	Deaths	Cases	Deaths	
1935	551	62	59	—	610	—	—
1936	477	59	129	15	606	74	12.2
1937	676	81	315	38	991	119	12.0
1938	882	81	170	29	1,052	110	10.4

Batavia reported 66 cases in 1935, 67 in 1936, 103 in 1937, and 140 in 1938. Semarang reported 82 in 1935, 67 in 1936, 155 in 1939, and 148 in 1938. Soerabaja reported 96 in 1935, 75 in 1936, 83 in 1937, and 120 in 1938.

Chapter X

MISCELLANEOUS INFECTIOUS DISEASES

Smallpox.—Although complete morbidity statistics are unavailable it appears that the disease is well controlled and that cases are rare. No epidemics have been reported in recent years. The following are the cases reported to the League of Nations, 1934–1938:

	1934	1935	1936	1937	1938
Java and Madoera	4	10	1	1	9
Other islands	5	33	79	0	3

De Rook (1938) states that there have been no epidemics in New Guinea since 1917 although the status of the disease in the interior is unknown.

An extensive vaccination program has been maintained since 1920. The statistics on the program are tabulated (from *Indisch Verslag*) in table 23.

The population of Java is about 42,000,000 and that of the other islands about 23,000,000. Hence it appears that no serious epidemics of smallpox should occur for the next few years assuming, of course, that the vaccination program continued up to the time of the invasion and occupation by Japanese forces. However it must be borne in mind that probably a very small portion of the natives of the interior of Borneo and New Guinea have been vaccinated.

TABLE 23.—*Summary of vaccination program*

Year	Java and Madoera					Other islands				
	Number of vaccinations	Controlled (observed)	Successful	Percent successful	Revaccinations	Number of vaccinations	Controlled (observed)	Successful	Percent successful	Revaccinations
1920	782,741	649,807	637,288	98.0	2,655,189	329,559	153,569	141,830	92.3	611,608
1925	1,108,250	884,968	828,641	93.6	1,843,712	378,634	134,601	122,110	90.7	775,317
1930	1,279,401	1,035,052	1,019,947	98.5	2,528,154	396,683	239,592	225,508	94.1	737,764
1931	1,284,482	1,051,528	1,038,786	98.7	2,490,779	428,484	262,685	247,409	94.2	817,563
1932	1,430,254	1,173,692	1,161,435	98.9	3,872,679	428,784	257,107	242,063	94.1	998,966
1933	1,416,244	1,166,903	1,154,420	98.9	4,675,937	420,195	254,781	241,267	94.6	1,077,703
1934	1,411,597	1,168,615	1,146,102	98.1	4,841,982	472,273	304,079	287,287	94.5	1,174,617
1935	1,375,366	1,139,417	1,125,763	98.8	4,042,015	474,173	314,117	298,489	95.0	1,118,649
1936	1,376,109	1,133,388	1,112,140	98.0	4,706,489	502,537	330,152	311,915	94.4	1,146,973
1937	1,157,342	935,078	920,341	98.4	4,103,502	513,188	335,286	318,079	94.8	1,297,067
1938	1,384,072	1,113,871	1,100,387	98.7	5,060,559	558,649	371,793	350,807	94.3	1,349,116

From *Indisch Verslag.*

Measles, mumps, scarlet fever, and chickenpox.—These diseases are not reported to the League of Nations by the Netherlands Indies Public Health Service. Actually the Public Health Service compiles no records of them except for hospitalized cases. There are about 200 to 500 recorded hospitalized cases of measles per year with a case fatality of about 5 percent. Recorded hospitalized whooping cough cases vary from 200 to 400 per year with 4 to 8 percent case fatality. There are practically no hospitalized cases of scarlet fever and chickenpox.

Poliomyelitis.—A few cases are reported each year. In 1936 nine were reported from Java of which four cases were at Soerakarta. Soerakarta reported one in 1937. Tarakan Island (near Borneo) reported five cases in 1936 and two in 1937. Medan (Sumatra) had two in 1937 and two in 1938. Poerworedjo (Java) reported one in 1937 and one in 1938. Bandoeng (Java) reported one case in 1938. Later statistics are not available.

Cerebrospinal meningitis.—Nine cases were reported for 1936, four for 1937, and nine for 1938. These were widely scattered throughout the archipelago.

Rabies.—Rabies is fairly common although the Public Health Service has not compiled statistics of its actual prevalence. Pasteur treatment has been used since 1895. Table 24 summarizes the number of treatments given at the Rabies Division of the Pasteur Institute at Bandoeng. It is probable that most, if not all, of these cases are from Java.

The rabies research program was for many years guided by Mrs. Otten-van Stockum whose work has been summarized in a posthumous publication (1941). The data in table 24 which show a higher mortality than the French figures are, of course, actually not a reflection on the

efficiency of the serum but rather of the difficulty of bringing the cases to treatment in sufficient time.

TABLE 24.—*Rabies treatment at Pasteur Institute in Bandoeng*

Year	Total admissions	Complete treatments	Deaths
1930	874	790	6
1931	813	741	9
1932	522	377	5
1933	607	516	6
1934	527	458	3
1935	778	726	3
1936	768	706	3
1937	753	696	6
1938	905	811	10

Cases of **rat-bite fever** have been reported but the disease is certainly uncommon.

There are occasional cases of **undulant fever** as would be expected because contagious abortion is prevalent in cattle. **Tetanus** has a prevalence similar to other tropical areas. **Anthrax** probably occurs on all of the islands. There are occasional epidemics preceded by epizootics in the water buffalo. **Melioidosis pseudomalleus (Whitmore's disease)** a glanders-like disease, occurs as a chronic pulmonary form or as a skin affection although recorded cases are rare. There are no records of **tularaemia.**

Trachoma.—Trachoma is prevalent especially in Java where examinations of school children in some areas show as many as 70 percent infected. The polyclinic in Tegal treats 50,000 cases of trachoma each year and the polyclinics in Brebes treat about 100,000 per year. Much of the treatment is performed by specially trained native nurses. Although the disease occurs throughout the archipelago little statistical information is available.

Skin Diseases

Skin diseases are very prevalent. Admissions for skin diseases (in percentages of total hospital admissions) for 1936 through 1939 were 12.37 percent, 12.38 percent, 12.22 percent, and 11.66 percent. The percentage admissions for malaria for the same years were 7.58 percent, 9.52 percent, 9.70 percent, and 11.66 percent. Ambulatory cases at dispensaries and polyclinics are extremely numerous and account for the majority of the cases which come to medical attention.

The following notes are from de Langen and Lichtenstein (1936) and from the notes of Dr. I. Snapper, Surgeon General's Office, United States Army.

Secondary infections of all skin ailments and abrasions are extremely numerous. **Scabies** is prevalent especially where water is less available; secondary infections are common. **Furunculosis** is common especially among Europeans.

Tropical ulcer (Ulcus phagedenicum tropicum) is a common ailment. It occurs most frequently on the anterior surfaces of the legs. It is most prevalent in New Guinea where it affects practically all Europeans. Throughout the archipelago it is one of the most frequent ailments treated at hospitals and polyclinics.

Fungus diseases of the skin are also prevalent. **Tinea imbricata** also known as *Dyak itch*, *Dajaksche schurft*, and *Dyak schurjt* is found throughout the archipelago although it is most prevalent in Borneo and on the Molukkas. This infection is also known as *Tokelau ringworm*. **Tinea albiginea** is common among the natives on all of the islands. It tends to be localized to the palms and soles. **Eczema marginatum,** also known as *epidermophytosis*, Hongkong foot, and dhobi itch, is another common skin disease. It occurs chiefly in the groins and

between the toes and occasionally in the axillae. A few cases of **mycetoma (Madura foot)** have been recorded.

Prickly heat (miliaria papulosa) occurs frequently among Europeans in the coastal areas when the humidity is high. **Pemphigus contagiosus,** also known as *monkey pox* and *impetigo bullosa tropica*, is also common especially where it is warm and humid.

Piedra with black nodules surrounding the hair is frequent among the Indonesians in Batavia where it is much more common among men than among women, and among the Dyaks of North Borneo where it is also common among women. Europeans are said to become infected very easily. Piedra with white nodules is rare in Batavia.

Red-bug dermatitis caused by hexapod trombiculid larvae is common, especially in New Guinea and Celebes.

De Rook (1936) discusses an acute dermatitis caused by "some plant substance" which occurs in the Upper Digoel country. He suggests that the plant involved is *Glutea bengha* (L.) or *Mangifera caesia* (Jack). The swelling of the face may be sufficient to prevent opening of the eyes.

Infections of foot wounds are frequent and must receive special attention.

Leprosy

Leprosy occurs throughout the archipelago. In 1936 there were 42 leper asylums. Since that time however there has been a change in policy on the part of the Public Health Service as described by Theunissen (1936). The use of leper asylums is relegated to secondary importance, with emphasis on effective local isolation, reporting and registrations by physicians, and strict supervision of treatment.

On the basis of reported cases a compilation of the incidence of the disease has been made in table 25. This is in part from the report of the Public Health Service (1937) to the League of Nations Conference on Rural Hygiene and in part from more recent data.

TABLE 25—*Prevalence of leprosy in the Netherlands Indies*

Island	Lepers	Lepers per 1,000 population
Java and Madoera	5,708	0.14
Bali	1,748	1.61
Lombok	350	.50
Sumatra and adjacent islands	3,268	.38
Lesser Soenda Islands	2,601	.70
Celebes	4,232	1.07
Borneo	373	.20
Molukkas, New Guinea, and adjacent islands	2,601	1.10
All islands	—	.30

In Java leprosy is particularly prevalent at Lamongan and Blora. Kapitan (1936) reports an incidence of 3 per thousand to 9.3 per thousand on the Kei Islands. De Langen and Lichtenstein (1936) speak of North Sumatra and the Molukkas as regions of high incidence.

Yaws

Yaws, known as *patek* in Java and *poeroe* among the Malayans, is a common disease in the Netherlands Indies. It occurs to a greater or less degree on all of the islands of the archipelago.

Recent reports by the Public Health Service state that it is very prevalent in Denak, Kediri, Tegal (19 percent of natives infected) and other areas in Java; Bali, Lombok and the other Lesser Soenda Islands, West Borneo, South and East Borneo, Madoera (about 10 per cent of the population infected) South Celebes, and the Molukkas. De Rook (1938) describes it as a prevalent contagious disease in the lower parts of New Guinea except in those areas occupied by the Marindanese.

Mass treatment with neosalvarsan was started in 1919. In recent years about 1,250,000 injections per year have been administered. The Dutch have employed an interest-

ing propaganda system in order to induce the natives to submit to treatment. Infected individuals were selected from families containing several cases and taken away for treatment. Treatment would be staggered so that on return to the village all stages from the first effects of neosalvarsan to complete treatment could be demonstrated. In this way it was possible to induce a large portion of the cases in a village to submit to treatment which was then conducted within the village. Mass therapeutic use of neosalvarsan has had two difficulties. In the first place there is a tendency for natives to stop coming for treatment as soon as there is some improvement but before complete cure has been effected. Also the Dutch physicians have found that some cases became refractory to neosalvarsan after several injections. Nevertheless the Public Health Service feels that mass treatment with neosalvarsan has effectively reduced the incidence of yaws.

Venereal Diseases

Venereal disease is prevalent especially in the cities. Simons (1941) has summarized the situation on the basis of the results of surveys. He concludes that 10 to 50 percent of the population between the ages of 18 and 50 in Java and Madoera are infected with venereal disease. The frequency is higher in the cities. About 50 percent of the cases never undergo treatment; 75 percent of the cases submitting to the first treatment do not continue it. Brothels flourish in the large cities. There are many quacks and quack medicines are used extensively. There is an old adage about curing native diseases with native drugs which is exploited by quack practitioners.

The Netherlands Indies Public Health Service Reports in *Indisch Verslag* for 1934–1940 show that about 7 percent of all hospital admissions are for venereal diseases. The case fatality averages about 1.5 percent. Naturally,

hospitalized cases represent a minute portion of the total numbers of cases. Annually about 18,000 cases, about 8,000 of which are syphilis, are treated by government dispensaries and polyclinics.

The prevalence of venereal diseases apparently is not as great in less densely populated areas. De Rook (1938) states that syphilis and gonorrhea are very uncommon in New Guinea except in the port cities.

Special mention should be made of **venereum granuloma** which has been reported only in New Guinea. The disease was described by de Rook (1938) as uncommon in Netherlands New Guinea except in the region of Merauke. It is more common in British New Guinea. The occurrence of this disease in New Guinea has been watched carefully by the Public Health Service. The results of its surveys are given in its Annual Report for 1937 (*Mededeelingen van den Dienst der Volksgezondheid in Nederlandsch-Indië*, 1939) and are tabulated in table 26.

TABLE 26.—*Venereum granuloma in New Guinea*

[Cases per 100 persons]

Region	Percent								
	1929	1930	1931	1932	1933	1934	1935	1936	1937
Koembe River	0.5	2.5	6.0	4.0	2.0	4.5	2.0	2.0	1.7
Boelaka River	—	—	7.5	—	2.0	1.0	2.0	2.5	1.5
Merauke River	—	3.5	1.5	3.5	1.0	—	.8	1.0	.8
Bian River	3.0	—	4.5	1.7	1.7	1.0	1.5	1.3	1.4
Coast, Merauke to Bian	—	—	—	—	—	—	.1	.1	.3
Coast, Merauke to Kondomiraf	2.0	—	5.0	.5	.5	1.0	.5	.6	.5
Janggandoer area	—	—	—	—	—	—	3.5	2.5	2.0
Eastern Frederick Hendrick Island	—	—	—	—	—	—	4.5	3.5	2.0
Western Frederick Hendrick Island	—	—	—	8.0	14.0	—	—	2.5	3.0

Only on the South Coast is *venereum granuloma* prevalent in Dutch New Guinea. No cases have been found in the Diogel region. Most of the cases are reported from Frederick Hendrick Island and along the Kali Bian, Kali Edi, and Boelaka rivers.

Chapter XI

HELMINTHIASES (OTHER THAN FILARIASIS)

Hookworm

Because of soil pollution by human feces and the barefoot habits of the natives, ankylostomiasis is extremely prevalent in the Netherlands Indies. *Actually there are more people with ankylostomiasis* than with any other single disease. About 90 percent of the worms are **Necator americanus** and 10 percent are **Ancylostoma duodenale.** In recent years the Public Health Service has conducted a campaign for the construction and use of latrines among the natives. This has resulted in the reduction of ankylostomiasis in many areas. According to de Langen and Lichtenstein (1936) it has been completely eliminated from the army and from many of the plantations. However among the native villagers ankylostomiasis continues undiminished. In its report to the League of Nations Conference on Rural Hygiene, the Public Health Service states that the incidence of hookworm among the natives in villages is 80 to 90 percent. One must bear in mind also that 90 percent of the population resides in villages. This report states that in 1924 it was found that the average number of worms per man was 81 and the average number per woman 62 and further that an investigation some years later revealed counts averaging 50 percent lower. Because of the small number of worms harbored per person most of the natives do not appear to be seriously affected.

The best summary of the geographical distribution of

hookworm is that of Amm (1933). He states that infections are particularly prevalent in Java and Sumatra (80 to 90 percent). However the greatest incidence is in Flores where the natives live under extremely unsanitary conditions in large family groups of 20 to 100 all in a large single-room house. Infection here is 100 percent and the number of worms per person is higher than elsewhere. Amm (1933) states that at altitudes of 3,500 feet, where there is no malaria, anemia is severe; hemoglobin readings indicate an average about 60 percent of normal. Two-fifths of the children die of ankylostomiasis on Flores. Since the time of Amm's investigation attempts have been made to remedy the situation. De Rook states that there are endemic centers of ankylostomiasis at Manokwari, Miei, Amberbaken, Sorong, FakFak, Merauke, and Tanah Merah in New Guinea. Elsewhere in the archipelago hookworm is prevalent although in general it is subclinical.

Ancylostoma brazilense, an intestinal parasite of cats and dogs, is prevalent. Occasionally it causes cases of creeping eruption in man.

Other Roundworms

Ascaris lumbricoides.—*Ascaris* infections are very numerous, according to some sources almost as numerous as hookworm infections. This is again correlated with improper disposal of feces and generally unsanitary conditions. Records of fecal examinations show 3 to 20 percent infected. It is stated that a careful survey would reveal a higher incidence at least in some areas. Ascariasis in the Netherlands Indies is usually subclinical.

Trichuris trichiura.—Apparently this worm is a common parasite in the Netherlands Indies. About 16 percent of the stool samples examined at the Eijkman Institute have trichurid eggs. Doubtlessly the incidence is greater than this in many areas.

Enterobius vermicularis and Strongyloides stercoralis also occur although there is no information on their prevalence.

Trichinella spiralis is known to occur although information is meager. Trichinosis has been reported among the Bataks in Sumatra and elsewhere in rats.

Cestodes

Bonne (1940) has summarized the information on the cestodes of the Netherlands Indies. **Taenia saginata** is the most common tapeworm. It is most prevalent among Europeans and less common among the Chinese; it is not found among the natives. **Taenia solium** is very uncommon. Most of the infections have been among the Chinese. **Dipylidium caninum** is uncommon in humans. **Hymenolepis nana** is also described by Bonne (1940) as uncommon in man. Bonne (1940) in another paper has described a single case of infection with **Bertiella studeri;** Bonne and Mreyen (1940) also described an infection with **Raillietina madagascariensis.**

Sparganosis has also been discussed by Bonne (1937). He states that a considerable number of rice-field workers around Batavia have been found infected. It is believed that the definitive host is the cat and perhaps some other mammals. *Cyclops* is the first intermediate host. The second intermediate host is a frog or, accidentally, man (producing sparganosis). Man is infected by drinking water containing *Cyclops* with procercoid larvae.

Trematodes

According to Bonne (1941) four *Echinostomidae* known to parasitize man occur in the Netherlands Indies:

1. **Echinostoma ilocanum** is quite common especially in asylums in Java. Sandground (1939) has studied this species in Java and reports that the first

intermediate host is a planorbid snail, *Anisus convexiusculus*. The cerceriae are reported to leave this snail and encyst as metacercariae on other species of snails, chiefly *Lymnea rubiginosa brevis*, *Vivipara javanica*, and *Pila conica*. He was able to obtain laboratory infections in white rats with the snails of these species bearing the metacercariae. The rice-field rat, *Rattus rattus argentiventer*, is a common host of *Echinostoma ilocanum*. Sandground treated 11 cases with tetrachlorethylene; 13 to 270 worms per person were passed.

2. **Echinostoma lindoensis,** formerly thought to be *E. ilocanum*, is abundant in the region around Lindoe Lake in the Celebes. Bonne and Sandground (1939) report one village in this region with 96 percent of the inhabitants infected with *Echinostoma lindoensis;* two other villages had infections of 44 and 24 percent respectively. It is stated that the intermediate host is a viviparous planorbid snail whose identity is not known (probably *Gyraulus* and *Viviparus*). Attempts to find reservoir hosts among wild birds and mammals have been unsuccessful. Laboratory rats and mice have been experimentally infected. This fluke has been reported only from the Lindoe Lake region of Celebes.

3. There has been a single record of infection by **Echinostoma malayanum.**

4. There is one record of **Echinostoma recurvatum.** It is rather common in the field rats.

There are no autochthonous records of **Clonorchis sinensis** although there are some cases among imported Chinese coolies. According to Brug (1936) several genera of snails known to be intermediate hosts elsewhere occur in the Netherlands Indies. He feels that the fact that the natives seldom or never eat raw fish accounts for the absence of autochthonous cases.

There also are no records of autochthonous cases of

Paragonimus westermani in the Netherlands Indies except possibly in New Guinea (Brug, 1936). There is no reliable information on the presence or absence of intermediate hosts. Since the natives do not eat raw crayfish it is improbable that **Paragonimus** will become established.

Fasciolopsis buski occurs in hogs but no human cases have been reported.

Schistosomiasis

Prior to 1937 no autochthonous cases of schistosomiasis had been reported. In that year Müller and Tesch (1937) reported an autochthonous infection of **Schistosoma japonicum** from Celebes. Subsequent investigations by Bonne et al. (1942) revealed the disease to be endemic in a considerable area around Lindoe Lake. *S. japonicum* adults occur not only in man but also in hogs and in deer. The worms in the deer attain a length of 3 mm. Natives infected in this area have enormously enlarged livers and spleens. Chronic peritonitis resulting in many adhesions is common. These authors were unable to reach any conclusions concerning the intermediate hosts. (See Appendix H.)

Chapter XII

ANIMALS AND PLANTS OF MEDICAL IMPORTANCE

Diptera

The role of mosquitoes (Family Culicidae) in the transmission of malaria, dengue, and filariasis has been discussed previously. Many mosquitoes, mostly culicines are of importance primarily as pests. (See List in Appendix D.)

Several genera of biting midges or punkies (Family Heleidae) are known to occur in the Netherlands Indies. *Culicoides*, *Lashiohelea*, *Leptoconops*, and *Stylconops* attack man. *Culicoides* species are frequently particularly annoying in mangrove swamps. Several species of black flies, *Simulium* spp., which attack man also occur. Several species of sand flies, *Flebotomus*, are present and may be potential vectors of kala-azar although Brug (1938) states that they are not sufficiently numerous to become vectors. The most important genera of Tabanidae from a medical standpoint are *Chrysops*, *Tabanus*, and *Chrysozone*. Thus far their medical importance has been only that of biting species although the *Chrysops* spp. must be regarded as potential vectors of onchocerciasis.

At least five species of houseflies (*Musca*) are known to occur in the Netherlands Indies. The domestic fly, *Musca domestica*, probably occurs only in the sea port cities where it has been introduced. It is unnecessary to discuss its role as a mechanical transmitter of disease. *M. sorbens* is probably the common housefly. Its habits are similar to *domestica* and it presents the same health hazards. *M. vicina* and *nebulo* also occur in the Netherlands Indies;

their habits are similar to those of *sorbens* and *domestica*. *M. vetutissima* is found throughout the archipelago and is the only species of *Musca* of medical importance known definitely to occur on New Guinea.

Stomoxys calcitrans, the stable fly or biting housefly, occurs throughout the archipelago. It can also be a mechanical transmitter of bacteria and protozoa.

Several species of the Family Caliphoridae of medical importance are recorded from the Netherlands Indies. *Chrysomyia megacephala* breeds in carrion and feeds on human feces. It is attracted to meats and sweets and can be an important mechanical transmitter of disease. It is also important in intestinal and wound myiasis. *Chrysomyia bezziana* attacks living tissue and is important in all types of myiasis. Three species of *Calliphora*, *C. fulviceps*, *C. malayana*, and *C. paradoxa*, have been reported from the western part of the archipelago; *C. augur* and *tesselata* are known from New Guinea. All five of these species breed in carrion and feed on feces and are potential mechanical transmitters of infection. They are rarely the cause of myiasis. The bottle flies *Lucilia papuensis* and *porphyruni*, have the habits of houseflies and may be of medical importance.

In the family Sarcophagidae, *Sarcophaga perigrina* (= *fuscicauda*) has habits similar to the houseflies. *S. dux* is a cause of tissue myiasis and *S. histipes* may contaminate milk and food. *S. ruficornis* is very important in wound myiasis.

Siphuncula funicula is a small nonbiting species. It is frequently referred to as an important cause of conjunctivitis. It may also be a transmitter of skin infections.

Siphonaptera (Fleas)

Information on fleas in the Netherlands Indies is somewhat scanty. The relation of fleas to typhus and the plague has been discussed previously. *Xenopsylla*

cheopis, the oriental rat flea, is common in the Netherlands Indies. It tends to be more numerous at altitudes higher than 1,000 feet. It is the important plague vector and doubtlessly the important typhus vector. *X. astia* rarely bites man. Its distribution has a tendency to be the greatest in the low country. Information of its geographical distribution and relation to disease in the Netherlands Indies is meager. *Pygiopsylla ahalae* (=*Stivalius cognatus*, mistaken identification) probably plays a minor role as a vector from rat to man but may be of importance as a rat-to-rat vector. It can be safely assumed that wherever there are rats (on practically all islands) rat fleas, *cheopis* at least, occur.

Ctenocephalides felis, the cat flea, which occasionally bites man probably has a general distribution wherever cats are found. On the other hand, the dog flea, *Ctenocephalides canis*, is thought not to be found in the Netherlands Indies. There are records of *Pulex irritans* although no indication as to its distribution and abundance. It is probably uncommon.

Anoplura (Lice)

Information on lice is likewise not abundant. According to Brug (1938) the body louse, *Pediculus humanus corporis*, is rare. This is said to account for the fact that there are no records of louse-borne typhus and relapsing fever. Brug (1938) explains the absence of body lice as due to the small amount of clothing worn by the natives. On the other hand head lice, *Pediculus humanus capitis*, is apparently common. The pubic louse, *Phthirus pubis*, is said to be uncommon among the natives because of the sparsity of pubic hair.

Bedbugs

No precise information has been found on the distribution and prevalence of bedbugs. However in the Nether-

lands Indies as in other tropical areas, the native bedbug is *Cimex hemipterus* (=*rotundus*) although *Cimex lectularis* has been introduced with the white population and occurs principally in the ports.

Mites

Information on the trombiculid mites (harvest mites) is very fragmentary. The taxonomy is confusing because most species are known only as larvae. The complete life history is not known for any of the Netherlands Indies species. The papers of Walch (1922, 1923, 1927) as well as the excellent account of Oudemans (1903) are the principal sources of information.

Adult trombiculids are believed to feed on decaying vegetable material in loose, moist surface soil, preferably humus where there is undisturbed wild vegetation. Eggs are deposited on the ground during the summer and autumn. The hexapod larvae soon emerge and attach themselves to various mammalian and avian hosts. It is believed that the larvae do not change hosts. A complete meal of blood is obtained from the first and only host after which the larva drops to the ground and metamorphoses into the octopod adult. The species which have thus far been described are tabulated in table 27. These data are from Walch's observation in Deli, Sumatra, (1922, 1923), in the Lampong Districts, in Sumatra (1927), and in Celebes (1927). No trombiculids were described by Walch as parasitizing humans in Celebes although others have shown that *T. wichmanni*, primarily a parasite of the Crown Pigeon, will attack man. Only *T. deliensis* is believed with certainty to be a vector of mite fever although *schüffneri* may possibly be a vector also. Several of the species are important in *red-bug itch.*

TABLE 27.—*Trombiculid larvae known to occur in Netherlands Indies*

Species	Known hosts	Color	Islands where known to occur	Remarks	Referen
T. deliensis	Man, rats, some birds	Yellow	Sumatra, Java	Mite fever vector	Walch (1922, 1923, 1927).
T. pseudo-akamushi	Man, rats, many other mammals, birds.	Bright red	Sumatra, Celebes	Very common in Sumatra.	Walch (1922, 1923, 1927).
T. acuscutellaris	Rats, man	Red	Sumatra	Very common on rats	Walch (1922, 1923, 1927).
T. pseudo-schüffneri	Man (one record)	Red	Lampong District, Sumatra.	Only a single record	Walch (1927).
Schöngastia indica (= *T. muris*).	Rats		Sumatra, Celebes	Common on rats	Walch (1922, 1927).
Leeuwenhoekia australiensis	Rats		Celebes		Walch (1927).
T. oudemansi	Rats	Yellowish-white.	Sumatra		Walch (1922, 1923, 1927).
T. globulare	Rats		Celebes		Walch (1927).
T. rara	?		Sumatra		Walch (1922, 1923).
T. densipiliata	Rats	Red			

Schöngastia salmi	?		Java	One record only	Walch (1927)
T. vandersandei	Man	Red	New Guinea	"Gonone"	Walch (1927).
T. wichmanni	Man, Crown Pigeon	Red	Celebes, New Guinea	"Gonone"	Walch (1922, 1923).
T. schüffneri (= *Neoschöngasati schüffneri*).	Man only	Red	Sumatra	Very common at Deli	Walch (1922, 1923).

(See Appendix F for table of morphological details useful in identification.)

The itch mite, *Sarcoptes scabiei*, is common. Its presence and the occurrence of scabies can be correlated directly with the scarcity of water and bathing facilities.

No information could be found concerning the occurrence of the follicle mite, *Demodex folliculorum*, although it appears safe to assume that it does occur.

Ticks

Krijgsman and Ponto (1932) conducted an extensive survey of the Netherlands Indies tick fauna. These authors recorded several species known to attack men. These are listed in table 28. It is very likely that many of these species have a wider distribution than that indicated in the table. At the present time no tick-borne diseases of man are known to occur.

TABLE 28.—*Ticks reported to attack man in the Netherlands Indies*

Species	Hosts	Known geographical distribution
Argas persicus	Birds, some mammals including dogs and man.	Java, Soemba.
Boophilus annulatus australis	Man and various other large mammals.	Western New Guinea, Tanimbar Island, Halmahera, Kariman Djawa.
Rhipicephalus sanguineus	Many species of mammals including man.	Soemba, Java, Madoera, Timor, Alor Island, Saparoea, Ambon, Sumatra.
Rhipicephalus haemaphysiloides	Many species of mammals including man.	Sumatra, Java, Madoera, Soembawa, Soemba, Timor, Aroe Island, Celebes.
Amblyomma testudinarium	Cattle, buffalo, man, wild hog.	Sumatra, Bali, Lombok, Borneo.

In addition Krijgsman and Ponto (1932) list 9 species of the genus *Haemaphysalis* which are parasites on mammals although none have been known to bite man. At

least seven species of *Amblyomma*, other than *testudinarium* which is known to attack man, occur on various mammalian and reptilian hosts. *Hyalomma aegyptus* has been reported only from cattle in Java. The two species of *Aponomma* occur only on reptiles. *Dermacentor auratus* has been recorded only from wild hogs and bears. *D. atrosignatus* which is known elsewhere to attack man has been found in British New Guinea. In general *Ixodes* is uncommon. *I. eichhorni* has been reported from British New Guinea as a parasite of man. There is also a single record of *I. holocyclus* from the Kei Islands near New Guinea. Nothing is known of its habits there. However in Australia it attacks man as well as many other mammals and birds and is known to be a vector of tick paralysis and Q fever.

Minning (1934) has rearranged the ticks of *Boophilus annulatus australis* into three species: *B.* (*Uroboophilis*) *rotundiscutatus*, *longiscutatus*, and *krijgsmani*. For practical purposes, however, the classification according to Krijgsman can still be used. Schultze (1937) recorded an undescribed *Boophilus* sp. from Soemba. Appendix E contains the keys of Krijgsman and Ponto (1932, translation) as well as a list of ticks known to occur in the Netherlands Indies.

Other Arthropods

Several species of blister beetles of the genera *Epicauta* and *Mylabris* are poisonous when eaten. These beetles are well known to the natives who refer to them variously as "wengwong," "areng-areng," "ireng-ireng," "endol-endol," "sopi," "wereng," and "sepihi."

According to Kopstein (1932) at least 10 species of scorpions are known to occur in Java; none are poisonous. Brug (1938) states that there are no truly poisonous

scorpions in the entire archipelago. The same is true for spiders, millepedes, and centipedes. Bites of these animals usually cause nothing more than local inflammation and swelling.

Leeches

Terrestrial bloodsucking leeches are found in the humid jungles and are not only pests but on occasion definite hazards. They are able to work their way through clothing in order to attach themselves and suck blood.

Enormous numbers of them may become attached to the legs and feet. Because of the anticoagulent in the saliva of these leeches the wounds heal slowly and are easily infected. According to Engelen (1935) the common leech in such attacks is *Haemadepsa javonica* although doubtlessly other species are involved. Abu Hanifah (1935) reports that not only is cutaneous hirudiniasis common but that cases of rectal, nasal, and vaginal hirudiniases are by no means uncommon.

Other Invertebrates of Medical Importance

According to Kopstein (1932) some species of the molluscan genus *Conus* occur in the Netherlands Indies and are poisonous. Clench and Yoshio Kondo (1943) describe the bite of *Conus* as painful and occasionally fatal. It is caused by teeth on the radula which detach on penetration or withdrawal. Poison is produced by a gland in the mouth.

Kopstein (1932) states that the medusae (jelly fish) of *Physalia utriculus* and *Dactylometra quinquecirrha* are dangerous to swimmers and fishermen. Contact with the tentacles of these species results in the discharge of their poisonous nematocysts. *Chiropsalmus quadrigatus* has not yet been reported from the Netherlands Indies although it is common in the Philippines.

Poisonous Snakes

Numerous species of poisonous snakes are known to occur in the Netherlands East Indies. However none of these species is abundant. Scientists who have traveled through these islands on expeditions are almost unanimous in reporting that poisonous snakes are difficult to find even when one is looking for them. Kopstein (1932) points out that in 1924, 171 hospitals reported only 132 snake bite cases and only 2 of these were fatal. He cites the statement of Mohnike who spent 25 years in travel and research which kept him in the jungles most of the time. During this period he observed only 3 fatal cases of snake bite. Nevertheless the danger does exist and it therefore seems advisable to mention the poisonous species most likely to be involved.

The taxonomy of snakes is complex and difficult. There is no simple key to the identification of the species. Frequently there are no common names. Whenever possible in this report both the common English and native names are included. There is no rule of thumb (size, color, markings, etc.) for distinguishing harmless from poisonous species. For practical first aid purposes, unless there is definite evidence to the contrary, all snake bites should be considered as poisonous. The rule that all poisonous bites have two fang penetration marks does not always hold in these regions.

In general the snakes of New Guinea and the adjacent islands are Australian species whereas those of the other islands (west of Wallace's Line) are Asiatic species.

Several species of pit vipers (Family Crotalidae) are found on the islands west of New Guinea (Java, Sumatra, Celebes, Borneo, etc.). All are poisonous. The bamboo viper (*Trimeresurus gramineus*) is arboreal with green coloration and a prehensile tail. It is mildly poisonous. Several species of this genus are found in the Netherlands

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Indies. Another pit viper, known among the natives as "ular biludak," "ular tanah," "ular gebuk," "ular bandotan bedor," and "oraj lemah" (*Agkistrodon rhodostoma*), occurs in Sumatra and Java. This species is gray or reddish brown dorsally with large dark brown pairs of dorso-lateral spots; it is very poisonous.

The most dangerous snakes are the cobras and kraits (Family Elapidae). The Indian or spectacled cobra (*Naja naja*) and its closely allied species also known as "ular sendoq," "ular bedul," "oraj sinduk," "oraj bobi," "ular biludah," "hantipeh pura," and "tedong naga" is the most deadly of the snakes of the archipelago. It is a nervous and irritable snake and strikes with a forward sweep of its body with an accompanying hiss. The king cobra (*Naja hannah*) is the largest of the poisonous snakes; it has an average length of 10 to 12 feet and a maximum length of about 18 feet. The native names are "ular tendong selar," "ular anang," and "oraj totok." It is found in the deep jungles of Borneo, Java, Sumatra, and Celebes. It is an aggressive species and will attack man. It is yellowish or olive-green apparently with black rings on the body. Three species of kraits also occur in Borneo, Celebes, Java, Sumatra, the Lesser Soenda Islands, and other islands west of Wallace's line. All are distinguished by transversely enlarged scales along the vertebral column. The poison is very virulent. Kraits are not aggressive although they have a habit of lying in the dust near paths where they may be stepped on. The common krait (*Bungarus candidus*) known by the natives as "ular weling" and "oraj weling," is lustrous black above with narrow white bands across the back. It is pearly white ventrally. This species is commonly found near human habitations because of its fondness for rats as food. The banded krait (*Bungarus fasciatus*) prefers jungle environments and is more sluggish. It is yellow above with broad

black rings. The yellow-headed krait (*Bungarus flaviceps*) is black with a red or yellow head. *Pseudelaps mülleri* and *Micropechis ikaheka* are members of the Australian fauna and are found in New Guinea. These species are potentially harmful. The death adder (*Acanthophis antarcticus*), a short clumsy snake, occurs in New Guinea and on the Molukkas. It varies in color always resembling the ground on which it lives.

Several pythons (Family Boidae) are found in the Netherlands Indies. Although these snakes are sometimes harmful as constrictors and biters they are nevertheless nonpoisonous.

Several species of sea snakes (Family Hydridae) live in the tropical waters of the Pacific and Indian Oceans. Usually they are found near the coast although sometimes they are observed far from land. They do not bite unless forcibly restrained.

An interesting fact to be noted is that the flesh of all snakes is edible regardless of whether they are poisonous or harmless.

The following is a list of Crotalidae and Elapidae known to occur in the Netherlands Indies:

Crotalidae. Occur only in Greater and Lesser Soenda Islands (Asiatic Region).

Trimeresurus gramineus
Trimeresurus puniceus
Trimeresurus monticola
Trimeresurus purpureomaculatus
Trimeresurus wagleri
Agkistrodon rhodostoma

Elapidae.

(a) Greater and Lesser Soenda Islands (Asiatic Region).

Bungarus fasciatus
Bungarus candidus
Bungarus flaviceps
Bungarus javanicus

Naja naja
Naja hannah
Maticora bivirgata
Maticora intestinalis
Callophis gracilis

(b) New Guinea and adjacent islands (Australian Region).

Acanthophis antarcticus
Micropechis ikaheka
Pseudechis scutellatus
Pseudechis papuanus
Pseudechis australis
Aspidomorphus (Pseudelaps) mülleri
Pseudapistocalamus nymani
Apistocalamus loriae
Apistocalamus pratti
Apistocalamus grandis
Apistocalamus lönnbergi
Ultrocalamus preussi
Toxicocalamus stanleyanus
Glyphodon tristis
Demansia (=Diemania) psammophis
Demansia (=Diemania) olivacea

Poisonous Fish

Fish may be poisonous in two ways: By having toxic substances in their flesh thereby causing poisoning when eaten, or by producing poisonous substances which can be introduced by means of barbs or spines.

Various species of puff toads or swell fishes (*Tetraodontidae*), known to the natives as "ikan boental", are poisonous when eaten. There have been many cases of fish poisoning on Nias Island (near Sumatra) due to *Clupea* (=*Harangula*) *perferata* or *Clupea fimbricata*, species closely related to the herring. *Clupea venosa*, a common salt water species in the waters of the Netherlands Indies, is also poisonous when eaten.

Synaeia verrucosa, known among the natives as "ikan neve" or "ikan laper" has special poison glands in con-

nection with its dorsal fin rays. It lies concealed in the sands where it may easily be stepped on thereby administering a foot wound. Local pain, swelling, lymphangitis, gangrene, fainting, and vomiting usually result. The The spines may also be contaminated with tetanus bacillus.

Inland in lakes and streams the best known poisonous fishes are the "catfish", *Clarius* and *Plotosus*, which may cause with their barbules, wounds which develop gangrene and necrosis. These species are known to the native as "ikan leleh" and "ikan semailang." They are common in rice fields.

Poisonous Plants

For information on poisonous plants in the Netherlands Indies reference should be made to the manual prepared by Dr. E. D. Merrill, "Emergency Food Plants and Poisonous Plants of the Islands of the South Pacific", War Department Technical Manual TM 10–420. Special attention is called to the physic nut (*Jatropha curcas*), castor oil plant (*Ricinus communis*), tree nettles (Laportea spp.), cowhage (*Mucuna* spp.), and *Semecarpus*.

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ABREVIATIONS USED

G. T. N. I., *Geneeskundig Tijdschrift voor Nederlandsch-Indië.*

M. D. V. N. I., *Mededeelingen van den Dienst der Volksgezondheid in Nederlandsch-Indië.*

T. v. E., *Tijdschrift voor Entomologie.*

Appendix A

KEYS TO THE IDENTIFICATION OF THE ANOPHELINE MOSQUITOES OF THE NETHERLANDS INDIES

These keys are translations, with some revision, of those of Swellengrebel and Rodenwaldt (1932), "Die Anophelen von Niederlandisch-Ostindien." They were chosen because they are the only keys available which have been prepared from Netherlands Indies material by entomologists with extensive experience in this area. In translation every effort has been made to use precise English equivalents. Terminology and nomenclature have been made to conform with Russell, Rozeboom, and Stone (1943). Whenever necessary diagrams, photographs, specimens, descriptions and other keys were consulted. However some disadvantages due to translation probably still exist. Of possibly further disadvantage is the fact that the Dutch use somewhat different characters in their keys than are used by entomologists in this country. Practice should eliminate this difficulty.

It is recommended that Russell, Rozeboom, and Stone (1943), "Keys to the Anopheline Mosquitoes of the World" be used as a complement to the keys of Swellengrebel and Rodenwaldt. In using the former, the keys for the Australian region should be used for material from New Guinea, the Molukkas, and adjacent islands whereas the Malayan key should be used for the western part of the archipelago, i. e., the Greater and Lesser Soenda Islands. The disadvantages of the keys of Russell, Rozeboom, and Stone are that they have been prepared primarily from Australian, Malayan, and Indian sources, keys and descriptions and are not as readily adaptable to the Netherlands Indies.

Key to the Identification of Male Anophelines of the Netherlands Indies

1. Wings not spotted-- 2
   Wings spotted--- 7
2. Light yellow wings---------------------------- *A. immaculatus*
   (This form is regarded by Christophers (1933) as synonymous with *A. vagus.* Swellengrebel and Rodenwaldt (1932) regard it as a variety of *A. sundaicus.*)
   Brownish wings-- 3
3. 2nd marginal cell very short (about ⅕ of petiole) or lacking----- 4
   2nd marginal cell of normal length-------------------------- 5
4. 2nd marginal cell very short------------------ *Bironella gracilis*
   2nd marginal cell lacking; the 2nd branch of the 1st vein present only at apical end-------------- *papuae* group. See Key A.
5. Palpus very short, about ¼ the length of the proboscis. Antennae as in females (not plumose)----------------- *B. travestitus*
   Palpus slightly shorter or the same length as the proboscis----- 6
6. Large mosquito (about 5 mm.) with bright forked scales on the head and tufts of scales on the prothoracic lobes-------------- -----------*Anopheles brevipalpis*
   Small mosquito (about 3.5 mm.) with narrow forked scales on the head. Prothoracic scales lacking---- *A. aitkenii.* See Key B.
7. Six ventral tufts of black scales projecting from the abdomen. Proboscis usually pale in its distal portion. (Some of the tufts of scales may be lacking.) One distinct tuft of scales is actually sufficient -- *A. kochi*
   Ventral abdominal tuft of scales lacking or if such are present, the proboscis, with the exception of the labella, is dark---------- 8
8. Apical portion of the femur of the hind leg with a broad tuft of very long white scales which is fused with a somewhat smaller black subapical tuft------------------------------ *A. annandelei*
   No tuft of scales on the posterior femur---------------------- 9
9. The distal end of the tibia which is often somewhat swollen and the adjacent basal part of tarsal segment of the hind leg are pale and appear as a wide pale area on the otherwise dark colored leg---- ------*A. leucosphyrus* and *A. l. hackeri.* See Key C.
   The tibio-tarsal joint of the posterior leg either not apparent or marked only by a small pale ring------------------------- 10
10. Tarsal segment 5 of the hind leg entirely white--------------- 11
    Tarsal segment 5 of hind leg in every case partly dark-------- 17
11. Tarsal segments 3–5 of hind leg entirely white--------------- 12
    Tarsal segment 3 of hind leg partly dark------------------ 13

Key to the Identification of Male Anophelines of the Netherlands Indies—Continued

12. Femora and tibiae of all legs and hind tarsal segment 1 spotted---- ---------------------------*A. ramsayi*
    Legs not spotted, at the most with scattered pale scales---------- ----------*fuliginosus* group. See Key I.
13. Tarsal segments 4 and 5 of hind leg entirely white------------ 14
    Only tarsal segment 5 of hind leg entirely white-------------- 15
14. Wing predominately pale. The costa shows from the base to the apex of the 1st branch of vein 2 at least 4 distinct pale areas. (Include the apical pale area at the 2nd vein.)-- *A. schüffneri*
    Wings, especially the costa, dark. The latter shows no more than 3 pale areas----------------- *A. hyrcanus pseudopictus*
    (The apical tarsal segment at its joint is somewhat brownish; the 4th tarsal segment may have a brownish band.)
15. Legs spotted---------------------------------- *A. maculatus*
    Legs not spotted-- 16
16. Palpus black with no more than indistinct small brown rings. Costa to apex of the 1st branch of vein 2 with only small pale spots---------------------- *A. albotaeniatus* and *montanus*
    Palpus with distinct wide yellowish white areas; costa with at least 4 pale areas--------------------------------- *A. karwari*
17. The costa from its base to the apex of the 1st branch of vein 2 with at least 3 pale areas------------------------------------ 18
    Costa with more than 4 pale areas------------------------- 21
18. The light areas at the tip of the wing only at the apex of vein 3 or lacking--- 19
    In the same place a pale area which extends at least across the apices of the 2nd branch of vein 2 and vein 3--------------- -----------------*hyrcanus* group. See Key D.
19. Two wide pale areas near the base and at the middle of the costa ---------------------*A. gigas sumatrana*
    Basal and median pale areas either lacking or small----------- 20
20. A pair of non-projecting groups of white scales on the II–VII abdominal segments ventral median or lateral. Whenever these are lacking there should be found on the posterior thoracic pleural sclerites at least 3–4 white hairs, usually there occur also from 3–20 white scales----------*barbirostris* group. See Key H.
    White scales on the ventral side of the abdomen and white scales as well as hair on the posterior thoracic pleural sclerites completely lacking------------------------------------ *A. umbrosus*

Key to the Identification of Male Anophelines of the Netherlands Indies—Continued

21. Veins 3 and 6 with no more than 3 spots------------------ 22
    Vein 3 and usually 6 with at least 4 small spots. Usually the number of spots on veins 2–6 larger and therefore each spot is smaller than in other mosquitoes giving the wings a speckled appearance which is more apparent in female. The legs are distinctly spotted. There is a possibility of confusion in the differentiation between *A. sundaicus* and *A. parangensis* on one hand with *A. tessellatus* and *A. longirostris* on the other. For the other members of this group (*A. leucosphyrus* with white tibio-tarsal bands and *A. punctulatus* with white scales on the mesonotum) the danger of confusion does not exist---------- *punctulatus* group. See Keys C and E.
22. Legs with small bands often imperceptible or almost lacking and also on the fore tarsus------------*Myzomyia* group. See Key F.
    Fore legs with obvious broad tarsal bands------------------ 23
23. Wing with 9–10 fringe spots not only at or near the apices of the veins but also between the branches of vein 5 and between veins 5 and 6--------------------------------- *A. parangensis*
    Wing with 7–8 fringe spots at or near the apices of the veins.---- -------------*Pseudomyzomyia* group. See Key G

Key to the Identification of Female Anophelines of the Netherlands Indies

1. Wings not spotted-------------------------------------- 2
   Wings spotted-- 7
2. Pale yellow wings------------------------------ *A. immaculatus*
   (This form is regarded by Christophers (1933) as synonymous with *A. vagus*. Swellengrebel and Rodenwaldt (1932) regard it as a variety of *A. sundaicus*.)
   Brownish wings-- 3
3. 2nd marginal cell very short (about ⅕ the length of petiole) or lacking--- 4
   2nd marginal cell of normal length------------------------ 5
4. 2nd marginal cell very short------------------*Bironella gracilis*
   2nd marginal cell not developed; posterior branch of second vein present only at apical end-------- *papuae* group. See Key A.
5. Palpus very short, about ¼ the length of the proboscis. ----------------------*B. travestitus*
   Palpus at least ¾ the length of the proboscis---------------- 6

Key to the Identification of Female Anophelines of the Netherlands Indies—Continued

6. Palpus about ¾ the length of the proboscis. Large mosquitoes (about 5 mm.) with broad forked scales on the head. Tufts of scales on the prothoracic lobe---------- *Anopheles brevipalpis*
   Palpus almost as long as proboscis. Small mosquitoes (about 3.5 mm.) with narrow forked scales on the head. Prothoracic scales lacking---------------------------- *A. aitkenii.* See Key B.
7. Abdomen when viewed dorsally with 6 tufts of lateral scales projecting from each side--------------------- *A. errabundus*
   These tufts of scales not present---------------------------- 8
8. From a lateral view 6 tufts of black scales extend ventrally from the abdomen. When the basal half of the palpus is mostly yellow or brown and only a small black ring is apparent, and also the distal end of the proboscis is pale, there may be fewer than 6 tufts of scales (possibly only 1)---------------------------- *A. kochi*
   Black tufts of scales are lacking on the abdomen or only a single tuft is present near the posterior end. Then, however, the palpus is entirely black or with a small pale ring and proboscis is dark with the exceptilon of the labella (specifically in *A. barbirostris* and *A. hyrcanus*)-- 9
9. The apical portion of the femur of the hind leg has a broad tuft of very long white scales which fuse with a subapical tuft of black scales which are somewhat less broad----------- *A. annandelei*
   No tufts of scales on the posterior femur-------------------- 10
10. The distal end of the tibia which is frequently somewhat swollen and the adjacent basal part of hind tarsal segment 1 are pale and stand out as a broad light spot in contrast to the rest of the dark colored leg. The wings are of the *punctulatus* type. (See couplet 22)-*A. l. leucosphyrus* and *A. l. hackeri.* See Key C.
    The tibio-tarsal joint of the hind leg is entirely dark or with only a small pale ring-------------------------------------- 11
11. Hind tarsal segment 5 is entirely white. (N. B. Particular attention should be given as to whether or not the base of hind tarsal segment 5 is black for that occurs only in *A. kochi* which is characterized by the ventral tuft of scales)--------- 12
    The hind tarsal segment 5 is partly dark in every case-------- 18
12. Tarsal segments 3–5 of hind leg entirely white--------------- 13
    Tarsal segments 5 or 4 and 5 of the hind leg entirely white---- 14
13. Femora and tibiae on all legs and hind tarsal segment 1 with pale spots on dark background. The pale area on the margin of the

Key to the Identification of Female Anophelines of the Netherlands Indies—Continued

wing at the apex of the second branch of vein 2 reaching to vein 3..*A. ramsayi*

Legs not spotted. At the most light scales are scattered among the dark. No light area at apex of posterior branch of vein 2..............................*fuliginosus* group. See Key I.

14. Tarsal segments 4 and 5 of hind legs entirely white........... 15

Only tarsal segment 5 of hind leg entirely white.............. 16

15. Wings predominately light colored. At least 4 pale spots on costa before apex of posterior branch of vein 2 ....*A. schüffneri*

Wings, especially costa, dark; at most with 3 distinct pale areas ....*A. hyrcanus pseudopictus* (probably *A. montanus*)

(N. B. The tarsal segment 5 may have at its joint some brown pigment and segment 4 may have a brownish band.)

16. Legs spotted (femora, tibiae and tarsal segments 1). Apical quarter of the palpus light, with a black band in the middle of the light portion..................................*A. maculatus*

Legs not spotted, palpus not as described.................. 17

17. Palpus black without apparent pale rings; costa up to the end of vein 2 with only 2 small pale spots.. *A. albotaeniatus* & *montanus*

Apical ⅖ of the palpus pale with two black rings within the pale area. Costa with at least 4 pale areas..........*A. karwari*

18. Palpus entirely black.. 19

Palpus with pale rings on a dark background (the light tip of the palpus is regarded as a ring)............................. 20

19. Palpus because of thickly set scales appear very thick and shaggy. The ventral tufts of scales apparent on abdominal segment VII from lateral view. Scales are apparent on the posterior thoracic pleural sclerites................*barbirostris* group. See Key H.

Ventral abdominal tuft of scales and scales on the posterior sclerites of the thoracic pleura lacking: palpus thinner and less shaggy.. ....*A. umbrosus*

20. Palpi with 3 pale rings and with black tips. The costa with 3 pale areas of which the basal is the broadest extending from 1st to 4th vein forming a wide basal pale area.. *A. gigas sumatrana*

Tip of palpus light... 21

21. The costa to the apex of the 1st branch of vein 2 with at the most 3 pale areas. Palpus with 3 or 4 pale rings. (The pale tips are counted as rings.) However, only the apical and subapical are readily noticeable.............. *hyrcanus* group. See Key D.

Key to the Identification of Female Anophelines of the Netherlands Indies—Continued

Costa to the apex of the 1st branch of vein 2 with at least 4 distinct pale spots -- 22

22. Veins 3 and 6 with not more than 3 spots. Palpus with 3 pale rings -- 23

Veins 3 and 6 with at least 4, usually 5 or 6 small spots. Palpus with more than 3 pale rings. Usually the number of spots on veins 2–6 is greater and therefore the individual spots are smaller than in other anophelines giving the wing a speckled appearance. The palpus with narrow black bands at bases of segments 4 and 5. Legs speckled ----------- *punctulatus* group. See Keys C and E.

23. The pale tip of the palpus is divided into two approximately equal parts by a dark band. The dark dividing band is either somewhat wider or usually narrower to much narrower than one of the 2 light parts; it may be reduced to a few dark scales. The proboscis frequently shows a more or less apparent light apical portion (labella, however, is always light). Legs entirely dark or with very small light bands at the joints -- *Myzomyia* group. See Key F.

Light tip of palpus divided with a black band so that the light part beyond the black band is 2–6 times as wide as the black band while the light part before the black band is significantly smaller than the apical light part -- 24

24. Wing with 9–10 fringe spots not only at or near the apices of veins but also between branches of vein 5 and between veins 5 and 6 -- *A. parangensis*

Wing with 7 or 8 fringe spots at or near the apices of the veins ----------- *Pseudomyzomyia* group. See Key G.

Key to the Anopheline Larvae of the Netherlands Indies

1. On all of the abdominal segments there are large anterior tergal plates (i. e., the tergal plate encloses the disc-shaped sclerotized plates which are found on the midline in the middle of each segment and usually entirely separated from the anterior tergal plates) -- 2

No anterior tergal plate of this size on the abdominal segments, at the most one on segment VIII (*papuae* group and *B. gracilis*) or the

Key to the Anopheline Larvae of the Netherlands Indies—Continued

tergal plates appear on all segments only somewhat (slightly) larger than normal (*Bironella travestitus*) ---------------- 4

2\. Small branched hair on the inner side of the antenna. The inner clypeal hairs are close together. Prothoracic hair no. 1 is palmate ------------------------------ *A. aitkenii palmatus*

No branched hair on the inner side of the antenna. The inner clypeal hairs are separated from each other. Prothoracic hair no. 1 is branched and with a thick stem ---------------- 3

3\. Inner clypeal hair with side hairs, posterior clypeal hairs branched. ------------------------------ *A. aconitus*

Inner and posterior clypeal hairs bare and unbranched --------- ----------- -------- *A. minimus* and *varuna*

4\. Small or large branched hair on inner side of the antenna ------ 5

This hair is lacking ---------------------------------- 15

5\. The hair on the inner side of the antenna is small, bearing a few branches -------------------------------------- 6

This hair is large, bearing many side branches and arises from the antenna half way or more from the base ---------------- 7

6\. One pair of thoracic palmate hairs ------ *A. aitkenii*. See Key B.

Two pairs of thoracic palmate hairs --- *papuae* group. See Key A.

No palmate hairs on the thorax ----------------------------- 6a

6a. No palmate hairs on the abdomen -------------- *A. brevipalpis*

Well developed palmate hairs on abdominal segments III–VII ----- ------------------------ *A. gigas sumatrana*

7\. Two pairs of palmate hairs on the thorax ------------------ 8

One pair or no palmate hairs on the thorax ----------------- 9

8\. Outer clypeal hairs with 4–6 branches. Prothoracic hairs nos. 1 and 2 slightly branched ---------------------- *B. gracilis*

Outer clypeal hairs branched at the most near the tip, prothoracic hairs 1 and 2 considerably branched ----------- *B. travestitus*

9\. Bases of inner clypeal hairs apparently far apart -- *A. albotaeniatus*

Inner clypeal hairs very close together -------------------- 10

10\. No palmate hairs on thorax and abdomen ---------------- 10a

Well-developed palmate hairs at least on abdominal segments IV and V -- 11

10a Outer clypeal hairs with many, branches 50–60 ---------------- --------------------- *A. umbrosus similissima*

Outer clypeal hairs with few, 5–16 branches --------------- 10b

10b. Outer clypeal hairs with 11–16 branches ----------- *A. separatus*

Outer clypeal hairs with 5–8 branches -- *A. umbrosus* and *A. hunteri*

Key to the Anopheline Larvae of the Netherlands Indies—Continued

11. Well developed palmate hairs only on abdominal segments IV and V. They are lacking on abdominal segments VI and VII and on thorax-- *A. novumbrosus*
    Well developed palmate hairs on abdominal segments III–VII-- 12
12. Prothoracic hair no. 1 unbranched or at the most branched once or twice near the tip------------------------------------ 12a
    Prothoracic hair no. 1 branched---------------------------- 13
12a. Outer clypeal hairs with 5–6 branches------------------------------------ *A. peditaeniatus* and *A. albotaeniatus*
    Outer clypeal hairs with 50–60 branches-- *A. hyrcanus*. See Key D
13. Inner clypeal hair without side hairs------------------------ 14
    Inner clypeal hair with side hairs, often thick and long------------------------ *A. bancroftii* and *pseudobarbirostris*
14. Outer clypeal hairs strongly branched------------ *A. barbirostris*
    Outer clypeal hairs weakly branched------------ *A. barbumbrosus*
15. Short but stout spines on the inner side of the antenna. Prothoracic hair no. 1 bulbous in the stem with radiating palmate hairs ----------------------------------*A. longirostris*
    No such stout spines on the inner side of the antenna. Prothoracic hair no. 1, if well developed never palmate----------------- 16
16. Posterior clypeal hairs are unusually long and extensively branched -----------------------*A. longirostris annulata*
    Posterior clypeal hairs are not as long and therefore not as strongly branched-- 17
17. The frontal hairs are unbranched; at the most the outer frontal hairs are forked. The inner frontal hairs are very short--*A. annandalei*
    All frontal hairs of about equal length, plumose-------------- 18
18. Outer clypeal hairs definitely plumose or branched . . . (Not to be confused with *A. hyrcanus* or *A. barbirostris* which have an antennal hair and whose inner clypeal hairs are close together)-- 19
    Outer clypeal hairs not as extensively branched-------------- 21
19. Inner clypeal hair with strong lateral branches-------*A. schüffneri*
    Inner clypeal hair without lateral branches------------------ 20
20. Posterior clypeal hair almost as long as the inner clypeal hair----------------------------------*A. incognitus*
    Posterior clypeal hair ⅓ as long as inner------------------- 20a
20a Posterior clypeal hair with three branches. Inner occipital hair unbranched. Bases of the prothoracic hairs fused. The filament

Key to the Anopheline Larvae of the Netherlands Indies—Continued

of the well-developed palmate leaflet almost as long as the body of the leaflet---------------------- *A. fuliginosus.* See Key I

Posterior clypeal hair with 5–8 branches; inner occipital hairs with 2–4 branches; bases of prothoracic hairs not fused; the filaments of the well-developed palmate leaflets ¼–½ as long as the body of the leaflet-------------------------------- *A. philippinensis*

21. Prothoracic hairs nos. 1 and 2 with well-developed bases---- - 22
Base of prothoracic hair no. 1 small-------------------- -- 25

22. Bases of the prothoracic hairs fused---------------------- --- 23
Bases of the prothoracic hairs not fused----------------- --- 24

23. Inner and outer clypeal hairs with side hairs, the latter are at least half the length of the former-------- *A. punctulatus moluccensis*
Inner clypeal at the most with fine side branches, outer clypeal hair short and entirely bare-- *A. leucosphyrus* and *hackeri.* See Key C

24. The palmate leaflets pointed---------------------- *A. maculatus*
The points appear as though cut off; the end of the leaflet is consequently blunt---------------------------------- *A. karwari*

25. Palmate leaflets with pointed ends but not drawn into filaments- 26
Palmate leaflets with obvious filaments------------------- 28

26. Middle and inner frontal hairs strongly branched------------ ---
-------------------*A. punctulatus punctulatus*
Middle and inner frontal hairs weakly branched------------- 27

27. Slightly pigmented yellow larva, occipital hairs long, unbranched or unforked. Prothoracic hair no. 1 light, about half the length of no. 2, with about nine branches. Antennae not pigmented----
------------------------------*A. kochi*
Dark larvae, occipital hair short, usually with three or four branches. Prothoracic hair no. 1 dark, about ¼ the length of no. 2, with 2–6 branches. Antenna mostly dark------------ *A. tessellatus*

28. Outer clypeal hair with four long branches----------- *A. amictus*
Outer clypeal hair unbranched; at the most, forked----------- 29

29. Posterior clypeal hairs short, nearer each other than the distance between the inner clypeal hairs; situated near the inner clypeal hairs (sometimes almost between them)-------------- *A. vagus*
Posterior clypeal hairs long, situated more posteriorly; distance between them about equal or greater than distance between inner clypeal hairs-- 30

30. Prothoracic hair no. 1, with obviously pigmented base and numerous (15) lateral branches. One of the long mesopleural hairs is

Key to the Anopheline Larvae of the Netherlands Indies—Continued

branched------------------------------------ *A. parangensis*
Prothoracic hair no. 1 with unpigmented small base and few (about 11) branches. Both long mesopleural hairs unbranched --------------*A. sundaicus* and *subpictus*

KEY A

papuae group

1. Basal arm of the male hypopygium long---------------------- 2
   Basal arm very short and compact with 4–5 toothlike setae on the end-- *B. soesiloi*
2. Lower half of the basal arm broad, apical half attenuated ending in a head not covered with hair---------------------- *B. derooki*
   Basal arm extended, cone shaped, covered with hair---- ------ 3
3. Basal arm with four long lancet-like processes at the apex- *B. papuae*
   Basal arm without these processes------------- *B. papuae brugi*

KEY B

A. aitkenii etc.

1. On the abdominal segments of the larvae there are tergal plates as in *aconitus* and *minimus* which cover about ⅔ of the segment--------------------------------- *A. aitkenii palmatus*
   No such dorsal abdominal plates on the larvae---------------- 2
2. Palmate leaflets notched so that the filament is separated sharply from the body of the leaf. Inner clypeal hairs branched or with side hairs or both-- 3
   Palmate leaflets only superficially notched so that there is no sharp division between filament and body. Inner clypeal hairs close together, unbranched and without side hairs---- *A. insulaeflorum*
3. Inner clypeal hairs unbranched and with side hairs------------- --------------*A. aitkenii* Type I
   Inner clypeal hairs forked and with side hairs---*A. aitkenii* Type II
   Inner clypeal hairs bifurcated or trifurcated, without side hairs---- --------------*A. aitkenii* Type III
   Inner and outer clypeal hairs forked five or six times----------- --------------*A. aitkenii* Type IV (*bengalensis*)

Key to the Anopheline Larvae of the Netherlands Indies—Continued

KEY C

A. leucosphyrus etc.

1. Tibio-tarsal joint of the posterior leg of the female and male marked with white. Female palpus with small light rings---- 2
   No "white heel" in the male and female. Female palpus with 2 or 3 small black rings on its distal half--------------------- 3
2. Rings on the palpus of the female very distinct, apical segment light for ¾ of its length. In the female the proboscis is only slightly longer than the palpus---------- *A. leucosphyrus leucosphyrus*
   Palpal rings not distinct in the female; apical segment light for less than half of its length. The proboscis of the female is much longer than the palpus-------------------- *A. leucosphyrus hackeri*
3. Abdominal segments II–VIII apparently covered thickly with scales dorsally and ventrally--------------------- *A. amictus*
   Abdominal scales at the most only on segments VI–VIII --------*A. punctulatus* and other species of *punctulatus* group

KEY D

hyrcanus group

1. Light apical fringe spot on the wing extending from a point slightly basal the apex of the 1st branch of vein 2 to apex of vein 3. Two small light rings nearly at the tip of the palpus of the female and very close to each other. Ventral tufts of scales on the VII abdominal segment of the female. Larvae with palmate hairs--3
   The above mentioned fringe spot extends only from the apex of the second branch of vein 2 to apex of vein 3. The above mentioned apical and subapical palpal rings are fused together into one. No ventral tufts of scales on VII abdominal segment of female. Larva without palmate hairs------------------------------- 2
2. Wings with broad pale costal areas at the apex of the subcosta. Phallosome with leaflets. Outer clypeal hairs of the larva with 11–16 branches; outer occipital hairs with 5–6 branches --------------*A. separatus*
   Wings with small pale costal areas at the apex of the subcosta. Phallosome without leaflets. Outer clypeal hairs of the larva with 1–2 branches------------------------------ *A. hunteri*

Key to the Anopheline Larvae of the Netherlands Indies—Continued

KEY D—Continued

hyrcanus group—Continued

3. Outer clypeal hairs of the larva with few (about 6) branches -------------- *A. peditaeniatus*
   Outer clypeal hairs of the larva with 50–60 side branches------ 4
4. Hind tarsal segments 4 and 5 entirely or almost entirely white. -------------- *A. hyrcanus pseudopictus*
   (See note in female keys concerning this subspecies.)
   None of the hind tarsal segments white or whitish-------------- 5
5. Wide white apical bands on the hind tarsal segments 2, 3, 4, and basal white bands on hind tarsal segments 4 and 5. Pale costal area at apex of subcosta small and not reaching vein 1. Long spot at base of stem of vein 5------------ *A. hyrcanus nigerrimus*
   Hind tarsal segments 2–5 with small white bands, only apical. Above mentioned pale costal area broader and reaching to vein 1. Spot at the base of vein 5 short-------- *A. hyrcanus sinensis*

KEY E

punctulatus group

1. Thoracic scales only on the anterior margin and lateral. Prothoracic lobe at the most with a few scattered scales. Abdominal scales only on the VIII segment. The second palpal segment of the female pale apically without black or yellow apical ring------- 2
   Thoracic scales on the entire mesonotum and scutellum. Prothoracic lobes with tufts of scales. Abdominal scales on segment VI–VIII. The second palpal segment of the female apically pale but in this apical pale part there is a subapical or apical black or yellow band-- 5
2. Proboscis of the female very long; about one-half again as long as the palpus. In the male the posterior legs including tarsal segments spotted--- 3
   Proboscis of the female of normal length. In the female the posterior legs only including tarsal segments spotted-------------- 4
3. Tarsal segments 1–4 of middle leg are brownish yellow. Hence the apical yellow bands of these segments are not apparent. Posterior clypeal hairs of the larvae short and nonbranched------------------ *A. longirostris*

Key to the Anopheline Larvae of the Netherlands Indies—Continued

KEY E—Continued

punctulatus group—Continued

Above mentioned tarsal segments black, the apical yellow bands showing conspicuously. Posterior clypeal hair of the larvae long, thick, and with 7–9 branches ---------------- *A. l. annulata*

4. Palmate leaflets of the larvae serrate --------------- *A. tessellatus*

Palmate leaflets of the larvae small with smooth edges ---------- -------------- *A. t. orientalis*

5. Proboscis of female often (with exception of the labella) entirely dark. Base of the no. 1 and 2 prothoracic hairs of the larva well developed and fused ---------------------- *A. p. moluccensis*

In the female the distal two-fifths of the proboscis is often pale colored. The prothoracic hair no. 1 of the larva has slightly developed base which is not fused with no. 2 ------ *A. p. punctulatus*

KEY F

Myzomyia group

1. All clypeal hairs of the larva unbranched and without side hairs. Proboscis either entirely dark with exception of the labella or only the apical third is pale on the ventral side. Vein 6 with two elongated spots. Vein 3 with a basal spot. Margin of wing without pale area at the apex of vein 6 --------------------- 2

Inner and outer clypeal hairs of the larva with side hairs, posterior clypeal hairs branched 3–5 times. Apical half of the proboscis is pale. Vein 6 with three short spots. Vein 3 without a basal spot. Fringe of the wing with a pale area at apex of vein 6 - *A. aconitus*

2. Female palpus with two (apical and subapical) pale rings separated by a single smaller dark ring. Basal third of the costa black, broken by pale areas. Three small spots on the stem and second branch of vein 5 (basal, tip, and bifurcation; the latter may be lacking). On the 1st branch of this vein there are 3 small spots - -------------- *A. minimus minimus*

Above mentioned white rings of the female palpus not broader than the intervening ring. Basal third of the costa black without intervening light areas. Spots on vein 5 especially the one at the apex of the 2nd branch are longer --------- *A. minimus varuna*

Key to the Anopheline Larvae of the Netherlands Indies—Continued

KEY G

Pseudomyzomyia group

1. Wings unspotted, pale yellow ---------- *A. immaculatus*
   (See note, couplet 1, female key.)
   Wings spotted ---------- 2
2. Legs spotted ---------- 3
   Legs unspotted ---------- 4
3. Spot on the 1st branch of vein 5 covers at least half of the branch. Beneath the second large costal spot (counting from the base of the wing) lie two spots on vein 1. Tip of the palpus of the female consists of a pale yellow apical and a black subapical part, both of about the same width ---------- *A. sundaicus*
   Biological Form I. Fresh Water. Inland in Sumatra.
   Biological Form II. Brackish Water. Throughout the range of the species.
   Spot on the 1st branch of vein 5 covers about a third of this branch. Beneath the second large costal spot (counting from the base of the wing) there are 3 spots on vein 1. The apical pale part of the female palpus is many times wider than the subapical black spot. (Breeds widely in fresh water) ---------- *A. ludlowi*
4. In the male the white ring at the joint between fore tarsal segments 3 and 4 is very small. In the female there is a very small pale spot or ring on the proboscis basad the labella. The tip of the palpus consists of a wide pale apex and a small subapical black part ($\frac{1}{4}$–$\frac{1}{5}$ the width of the pale part). Larvae with short outer clypeal hairs ($\frac{3}{5}$ the length of the inner clypeal hairs). The posterior clypeal hairs are short, close together and placed quite far anteriorly, almost between the inner clypeal hairs ---------- *A. vagus*
   In the males there is a broad pale band on the joint between tarsal segments 3 and 4 of the anterior leg. In the female the proboscis with the exception of the labella is entirely dark. The outer clypeal hairs of the larvae are about $\frac{6}{10}$–$\frac{8}{10}$ the length of the inner clypeal hairs. The posterior clypeal hairs are far apart and situated well to the posterior ---------- 5
5. Tip of the palpus of the female with white and black parts of the same width ---------- *A. subpictus*
   The width of the white part is at least twice that of the dark subapical part ---------- *A. subpictus malayensis*

Key to the Anopheline Larvae of the Netherlands Indies—Continued

KEY H

barbirostris group

1. Outer clypeal hairs of the larva with few, 17 or less, branches. Adult cannot be separated from *Anopheles barbirostris* ---------------------- *A. barbumbrosus*
   Outer clypeal hairs of the larvae with at least 40 branches usually many more (about 60) -- 2
2. The usual pale area of *A. barbirostris* at the apex of vein 3 is lacking. On the other hand such areas occur at the apices of one or both branches of vein 4. The femora and tibiae as well as all tarsal segments of all the legs show spotting due to scattered white scales. The inner clypeal hair of the larva with side hairs---- 3
   Light area at the apex of vein 3 but not at the apex of vein 4. Legs not spotted. Inner clypeal hair bare---------- *A. barbirostris*
3. Fringe spots at apices of veins 1, 1st branch of 2, both branches of 4, and vein 5---------------------------------- *A. bancroftii*
   Fringe spots only at apices of vein 1, 1st branch of 2, and 1st branch of 4---------------------------------- *A. pseudobarbirostris*

KEY I

fuliginosus group

1. In the male and female the bifurcation of vein 5 black. Hind tarsal segment 2 with white apex, ⅕ of the length of the segment. The inner occipital hair of the larva usually unbranched----------------------- *A. fuliginosus*
   In the male and female the bifurcation of vein 5 is not black. Hind tarsal segment 2 with white apex almost half as long as the segment. Inner occipital hair of the larva with 3–7 branches----- 2
2. White scales scattered on the ventral side of the abdomen. Palmate leaflets of the larvae with long filaments-------- *A. pallidus*
   No white scales on abdomen. Palmate leaflets of the larvae with short filaments-------------------------- *A. philippinensis*

Appendix B

CHECK LIST OF THE ANOPHELINES OF THE NETHERLANDS INDIES

The following list of anopheline mosquitoes has been compiled from Overbeek and Stoker (1938), Brug (1938), and Swellengrebel and Rodenwaldt (1932). It represents a consensus of opinion of Dutch investigators and is probably as accurate a check list as can be prepared from the literature at the present time. The nomenclature is that used by Russell, Rozeboom, and Stone (1943) which adheres closely to that of Christophers (1933). The accepted Dutch names as given by Swellengrebel and Rodenwaldt (1932) are included parenthetically when they differ with those of Russell, Rozeboom, and Stone (1943).

Australian Species

Anopheles (*Myzomyia*) *meraukensis* Venhuis, 1932.

A. (*M.*) *amictus* Edwards, 1921.

A. (*M.*) *longirostris* Brug, 1928 (=*punctulatus longirostris*).

A. (*M.*) *punctulatus punctulatus* Doenitz, 1901 (=*punctulatus typicus*).

A. (*M.*) *p. moluccensis* Swellengrebel and Swellengrebel de Graaf, 1920 (=*punctulatus* var. *moluccensis*).

A. (*M.*) *p. novaguinensis* Venhuis, 1933 (=*punctulatus typicus* var. *novaguinensis*).

A. (*M.*) *incognitus* Brug, 1931.

A. (*Anopheles*) *bancroftii bancroftii* Giles, 1902 (=*barbirostris bancrofti*).

A. (*A.*) *stigmaticus stigmaticus* Skuse, 1888.

Bironella travestitus Brug, 1928 (=*Anopheles travestitus*).

B. papuae (Swellengrebel and Swellengrebel de Graaf), 1920 (=*A. papuae typicus*).

B. soesiloi Strickland and Chowdhury, 1931 (=*A. papuae soesiloi*).

B. derooki Soesilo and van Slooten, 1931 (=*A. papuae de Rooki*).

B. gracilis Theobald, 1905 (=*A. bironelli*).

B. walchi (Soesilo) 1932 (=*Brugella walchi*).

B. papuae brugi (Soesilo and van Slooten) 1931 (=*A. papuae typicus* var. *brugi*) and *A.* (*M.*) *longirostris annulata* Brug, 1930 (=*punctulatus longirostris* var. *annulata*) are of uncertain taxonomic status.

Asiatic Species

Anopheles (*Anopheles*) *brevipalpis* Roper, 1914.

A. (*A.*) *gigas formosus* Ludlow, 1909 (=*gigas* var. *formosus*).

A. (*A.*) *gigas sumatrana* Swellengrebel and Rodenwaldt, 1932.

A. (*A.*) *aitkenii aitkenii* James, 1903.

A. (*A.*) *aitkenii palmatus* Rodenwaldt, 1927.

A. (*A.*) *insulaeflorum* (Swellengrebel and Swellengrebel de Graaf), 1920 (=*aitkenii* var. *insulaeflorum*).

A. (*A.*) *separatus* (Leicester), 1908 (=*hyrcanus separatus*).

A. (*A.*) *baezai* Gater, 1933.

A. (*A.*) *umbrosus* Theobald, 1903.

A. (*A.*) *novumbrosus* Strickland, 1916 (=*umbrosus* var. *novumbrosa*).

A. (*A.*) *hunteri* Strickland, 1916 (=*hyrcanus hunteri*).

A. (*A.*) *montanus* Stanton & Hacker, 1913 (=*albotaeniatus* var. *montana*).

A. (*A.*) *albotaeniatus* Theobald, 1903.

A. (*A.*) *barbumbrosus* Strikland and Chowdhury, 1927 (=*barbirostris* var. *barbumbrosus*)

A. (*A.*) *bancroftii barbiventris* Brug, 1938.

A. (*A.*) *barbirostris* van der Wulp, 1884 (=*barbirostris typicus*).

A. (*A.*) *pseudobarbirostris* Ludlow, 1902 (=*bancrofti* var. *pseudobarbirostris*).

A. (*A.*) *hyrcanus sinensis* Wiedemann, 1828.

A. (*A.*) *h. nigerrimus* Giles, 1900 (=*hyrcanus typicus* var. *nigerrima*).

**A.* (*A.*) *h. pseudopictus* Grassi, 1899 (=*hyracanus typicus* var *pseudopicta*).

A. (*A.*) *annandalei* Baini Prashad, 1918 (=*annadalei* var. *djajasanensis*).

A. (*Myzomyia*) *karwari* James, 1903. (Occurs in New Guinea also.)

A. (*M.*) *kochi* Doenitz, 1901.

A. (*M.*) *tessellatus* Theobald, 1901 (=*punctulatus tesselatus*).

A. (*A.*) *leucosphyrus leucosphyrus* Doenitz, 1901.

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*Probably ***A. montanus*****, mistaken determination.**

A. (*M.*) *l. hackeri* Edwards, 1921 (=*leucosphyrus* var. *hackeri*).
A. (*M.*) *minimus minimus* Theobald, 1901.
A. (*M.*) *m. flavirostris* Ludlow, 1914.
A. (*M.*) *aconitus* Doenitz, 1902.
A. (*M.*) *schüffneri* Stanton, 1915.
A. (*M.*) *annularis* van der Wulp, 1884 (=*fuliginosus typicus*).
A. (*M.*) *pallidus* Theobald, 1901 (=*fuliginosus pallidus*).
A. (*M.*) *philippinensis* Ludlow, 1902 (=*fuliginosus philippinensis*).
A. (*M.*) *vagus* Doenitz, 1902.
A. (*M.*) *subpictus* Grassi, 1899.
A. (*M.*) *sundaicus* Rodenwaldt, 1926 (=*ludlowi* var. *sundaica*).
A. (*M.*) *ludlowi* Theobald, 1901. (Ceram only.)
A. (*M.*) *parangensis* Ludlow, 1914.
A. (*M.*) *maculatus maculatus* Theobald, 1901.
A. (*M.*) *errabundus* Swellengrebel, 1925.
A. (*M.*) *ramsayi* Covell, 1927.

A. (*M.*) *flavescens* Swellengrebel and Rodenwaldt, 1921 is a form of uncertain taxonomic status described by Swellengrebel and Rodenwaldt (1932) as similar to *sundaicus* and by Christophers (1933) as a possible synonym of *sundaicus*.

A. (*M.*) *immaculatus* James, 1902 is also of undetermined taxonomic status. Swellengrebel and Rodenwaldt (1932) consider it as close to *sundaicus* whereas Christophers (1933) considers it synonymous with *vagus*.

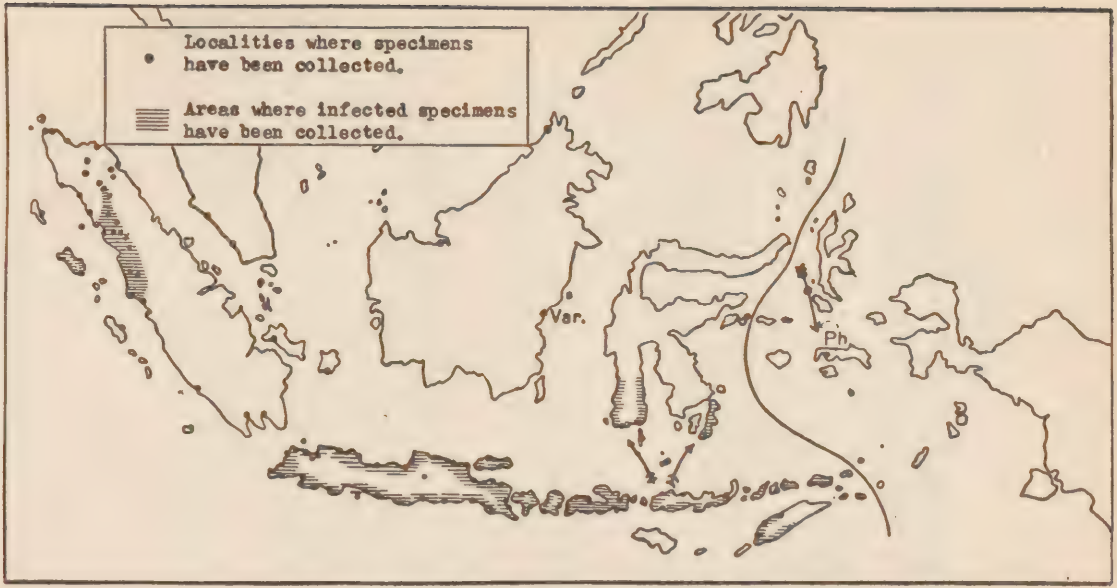
Swellengrebel and Rodenwaldt (1932) record *A.* (*M.*) *tessellatus orientalis* Swellengrebel and Swellengrebel de Graaf, 1920 (=*punctulatus tesselatus* var. *orientalis*) from Celebes, Ceram, and Boeroe. This was originally described as a variety of *punctulatus*.

Appendix C

DISTRIBUTION OF MALARIA VECTORS IN THE NETHERLANDS INDIES

The maps and data in this appendix have been compiled largely from the monograph of Swellengrebel and Rodenwaldt (1932). A note of caution must be injected concerning possible extension of some species since the writing of this monograph, such as the expansion of *sundaicus* into Celebes. Further it must be emphasized that the maps and lists include only the positive collecting records of the species i. e. collecting localities where a given species was not found have not been recorded on the maps as such. Nevertheless, with the exception of Borneo, these maps do give a fairly reliable picture of the distribution of the important vectors.

Localities listed and given on the maps are those stations where the given species *has been collected and is known to occur*. Naturally they do not represent the only places where the species will be found. Areas where the various species have been recorded as definitely infected are shown with hatching. These data are compiled from various sources and are incomplete. It is only safe to assume that any one of these species is at least potentially a vector throughout its range in the Netherlands Indies.



1. (Appendix C.)—*Anopheles sundaicus.*

Anopheles sundaicus

ISLAND OF JAVA: West Java: West Bantam, South Bantam, North Bantam, Batavia, Tandjong Priok, Serang, Wijnkoops Bay, Sindangbarang, Genteng, Kepetakan, Cheribon. **Middle Java:** Tjilatjap, Babakan, Noesa kambangan, Gombong, Tegal, Semarang, Demak, Solo, Margaredjo. **East Java:** Toeban, Coast of Madioen Residence, Kediri Coast, Soerabaja, Pasoreosan, Probolinggo, Kraksaän, Besoeki, Panaroekan, Banjoewangi, Coast along Madoera Strait, South coast of Loemadjang, South coast of Djember, Coast of Madoera Island.

ISLAND OF SUMATRA: Atjeh: Kotaradja, Meulaboh, Singkel, Tapatoean, Lho Soekon, Olehleh, Sigli, Lho Seumawe, Tjalang, Bireuën, Kroëngradja. **East Sumatra:** Coast of Deli, North coast of Lake Toba, Lao Balang, Belawan (Deli) Samosir. **West Sumatra:** Sibolga, Padang Sidempoean, Greater Mandailing, Lesser Mandailing, Pangoeroeran, Pahahi Plain, Rao, Angkola djoeloe, Fort v. d. Capellen, Lake Manindjau, Naras, Emmahaven. **South Sumatra:** Benkoelen, Lampongs.

ISLAND OF BORNEO: Local variety in Koeala Sambodja near Balikpapan.

ISLAND OF CELEBES: Bonthain. (Apparently the range in Celebes is expanding.)

OTHER ISLANDS: Poelau We, Simaloer, Nias, Siberoet, Enggano, Banjak Island, Anambas Island, Riouw Archipelago, Banka, Billiton, Edam, Bali, Lombok, Soembawa, Salajar, Flores, Alor, Pantar, Timor: (towns of Koepang, Wini, Atapoepoe) Wetar, Roma, Leti, Laboehan marege (Djampea group), Boetoeng.

**Anopheles ludlowi immaculata*

ISLAND OF JAVA: Soerabaja.
ISLAND OF SUMATRA: Greater Mandailing, Deli.
OTHER ISLAND: Soembawa.

Anopheles ludlowi

ISLAND OF CERAM: Piroe (Molukkas).

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*(Reported by Swellengrebel & Rodenwaldt (1932). Taxonomic status uncertain.)

2. (Appendix C.) *Anopheles subpictus.*

Anopheles subpictus

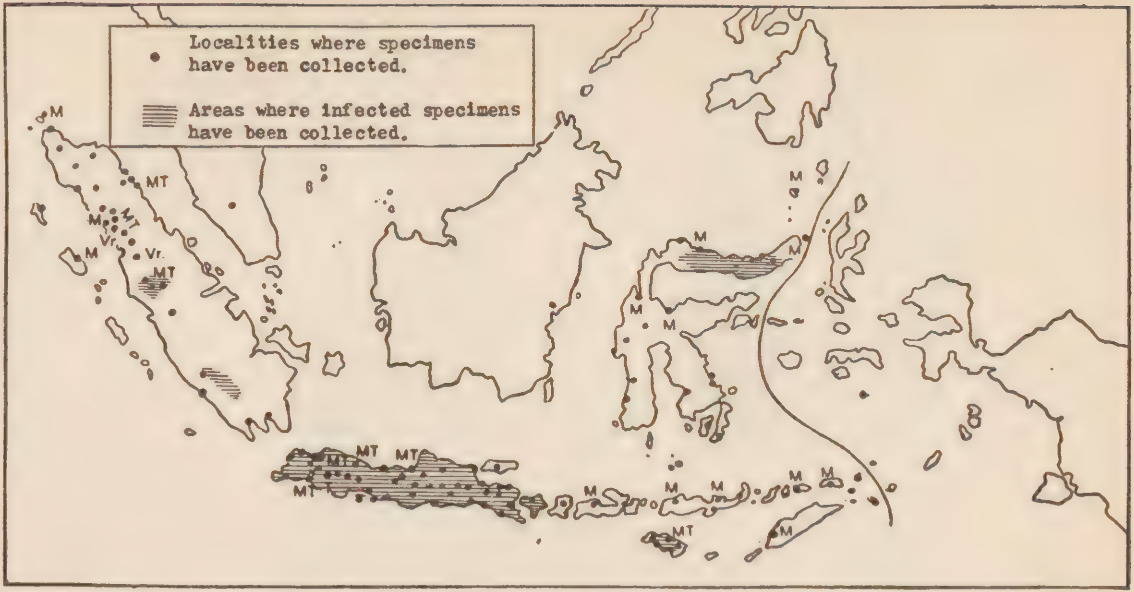
ISLAND OF JAVA: West Java: West Bantam, East Bantam, North Bantam, South Bantam, Tegal wangi, Tjikadoe, Serang, Batavia, Tandjong Priok, Soekaboemi, Tjiheha Plain, Djampang Region, Bandoeng Plain, Soemedang, Cheribon, Kepetakan, Bandjar. **Middle Java:** Tjilatjap, Noesa kambangan, Babakan, Gombong, Tegal, Semarang, Margaredjo, Coast of Rembang Residence, Solo, Magelang. **East Java:** Coast of Madioen Residence, Coast of Kediri Residence. Modjowarno, Soerabaja, Coast along Madoera Strait, Pasoeroean, Probolinggo, Kraksaan, Besoeki, Panaroekan, South Loemadjang, South Djember, Banjoewangi, Madoera Island.

ISLAND OF SUMATRA: Atjeh: Kotaradja, Lho Seumawe, Lokop, Bireuën, Olehleh, Kroëngradja. **East Sumatra:** North coast of Toba Lake. **West Sumatra:** Sidikalang. **South Sumatra:** Lampongs: (Uncertain) Kroë, Singkarak, Solok, Pahahi Plain, Mentawei Island.

ISLAND OF BORNEO: Balikpapan.

ISLAND OF CELEBES: Boekoekoemba, Balang Nipa, Kolaka, Bonthain, Makassar, Barroe, Parepare, 'Polewali, Madjene, Mamoedjoe, Boeol, Tolitoli, Leok, Kotamobagoe, Kendari.

OTHER ISLANDS: Nias, Siberoet, Poelau We, Banka, Billiton, Bali, Lombok, Soembawa, Timor (Koepang), Alor, Panta, Wetar, Roma, Poelau Laoet, Djampea, Boeton, Moena, Bonerate, Salajar, Boeroe, Ambon, Haroekoe, Ceram, Gesar, Soela Islands, Halmahera, Ternate, Batjan, Misool, Goram Island.



3. (Appendix C.) *Anopheles aconitus* and *A. minimus.*
T.—*A. aconitus* M.—*A. minimus* Vr.—*A. varuna*

Anopheles aconitus and *A. minimus*

T.—*A. aconitus* M.—*A. minimus* Vr.—*A. varuna**

ISLAND OF JAVA: West Java: West Bantam, South Bantam, East Bantam, Tegal wangi, Tjikadoe, Serang, Batavia, Tandjong Priok, Buitenzorg, Soekaboemi, Wijnkoops Bay (T. M.), Djampang (T. M.), Tjiheha Plain (T. M.), Bandoeng, Soemedang, North Soemedang (T. M.), Bandjar. **Middle Java:** Tjilatjap, Noesa kambangan, Gombong, Tegal, Batoer, Semarang (T. M.), Oengaran, Kedong Kebo, Willem I, Magelang, Solo, Babakan. **East Java:** Inland and Coast of Madioen Residence, Modjowarno, Modjokerto, Kediri, Djatirogo, Soerabaja, Malang, Tambaksari, North Coast of Java along the Madoera Straits, entire South coast of East Java, South Loemadjang, Sitoebondo, Banjoewangi, Island of Madoera.

ISLAND OF SUMATRA: Atjeh: Kotaradja (T. M.), Lokop, Belang kedjeren, Bireuen, Seulimeum, Tapatoean, Kroengradja (M.), Takengon, Kotatjane, Seroewai. **East Sumatra:** Coast of Deli, Deli Plain, Kisaran (M. T.), Lao Balang (M. T.). **West Sumatra:** Angkola djoeloe (T. M.), Padang Sidempoean (M. T.), Greater Mandailing (M. T.), Moeara laboeh (T. M.), Batang toroe (Vr.), Loeboek Sikaping (T. M. Vr.), Angoli (T. M.), Rao, Soendatar (T. M. Vr.), Pahahi Plain, Kajoetanam, Sidikalang, Fort de Kock, Padang Pandjang, Fort v. d. Capellen (T. M.). **South Sumatra:** Benkoelen, Ketahoen-Plain, Moeara aman, Tjoeroep, Lampongs.

ISLAND OF BORNEO: Balikpapan.

ISLAND OF CELEBES: Makassar, Rapang, Madjene, Toradja Region, Mandar, Paloe (M.), Boeol (M.), Paleleh (M.), Menado, Posso (M.), Palopo and Toma Plain, Kotamobagoe, Kolaka, Moeara Bay, Kendari.

OTHER ISLANDS: Sabang (M.), Simaloer, Nias (M.), Bali, Lombok, Soembawa, Flores (M.), Soemba (M. T.), Alor (M.), Wetar (M.), Pantar, Timor (Koepang) (M.), Roma, Babar, Kisar, Sangihe (M.), Talisai (M.), Boeton, Moena.

*Reported only by Swellengrebel and Rodenwaldt (1932), Weyer (1939), Christophers (1933), and Overbeek and Stoker (1938) do not agree. Probably erroneous identification.

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4. (Appendix C.) *Anopheles maculatus.*

Anopheles maculatus

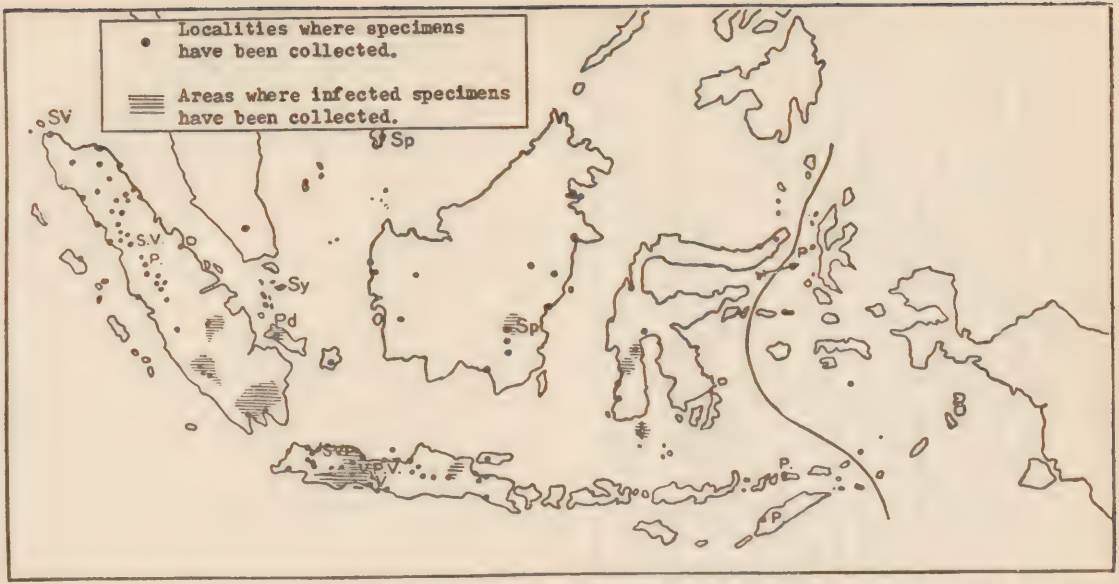
ISLAND OF JAVA: West Java: East Bantam, Tjikadoe, Soekaboemi, Djampang Region, Buitenzorg, Poentjak, Tasikmalaja, North Soemedang, South Soemedang, Bandjar. **Middle Java:** Batoer, Wonosobo, Bandjarnegara, Noesa kambangan, Semarang, Banjoe biroe. **East Java:** Madioen Residence, Soerabaja, Malang, South Malang, Kali Rawaan, South Banjoewangi, Madoera Island.

ISLAND OF SUMATRA: Atjeh: Takengon, Belang kedjeren. **East Sumatra:** Kisaran, Karoo Plain. **West Sumatra:** Sidikalang, Sibolga, Pandang Sidempoean, Greater Mandailing, Soendatar, Angkola djoeloe, Limau manis, Loeboek soelasih, Fort de Kock, Padangpandjang, Kajoetanam, Naras, Emmahaven, Angoli, Sawah Loento, Sandaran agoeng, Moeara laboeh. **South Sumatra:** Moera aman, Ketahoen Plain, Pager alam, Doerian.

ISLAND OF BORNEO: Upper Mahakam.

ISLAND OF CELEBES: Toradja-Lander, Watampone, Balangnipa.

OTHER ISLANDS: Nias, Enggano, Riouw, Banka, Natoena, Anambas, Boeton, Flores, Timor: (Koepang, Atamboea), Alor, (Aroe).



5. (Appendix C.) *Anopheles hyrcanus* group.

S.—*A. hyrcanus sinensis*
V.—*A. hyrcanus nigerrimus*
P.—*A. hyrcanus pseudopictus*
Sp.—*A. separatus*
Pd.—*A. peditaeniatus*
H.—*A. hunteri*

Anopheles hyrcanus group

S.—*A. hyrcanus sinensis*
V.—*A. hyrcanus nigerrimus*
P.—**A. hyrcanus pseudopictus*
Sp.—*A. separatus*
Pd.—*A. peditaeniatus***
H.—*A. hunteri*

*Probably *hyrcanus nigerrimus.*
**Probably *A. montanus.*

ISLAND OF JAVA: West Java: West Bantam, East Bantam, South Bantam, Batavia (S. V. P.), Tandjong Priok (P.), Buitenzorg, Tjitjoeroeg, Soekaboemi, Tjiheha Plain, Bandoeng Plain, North Soemedang, Tjikadoe, Tegal wangi, Bandjar, Kepetakan (V. P.), Cheribon (V. P.). **Middle Java:** Tjilatjap (V.), Babakan, Gombong, Poerworedjo, Tegal (V.), Pekalongan, Semarang, Magelang, Ambarawa (P.), Banjoe biroe, Solo. **East Java:** Madioen Residence, Lamongan, Modjowarno, Soerabaja, Probolinggo, South Loemadjang, Madoera Island.

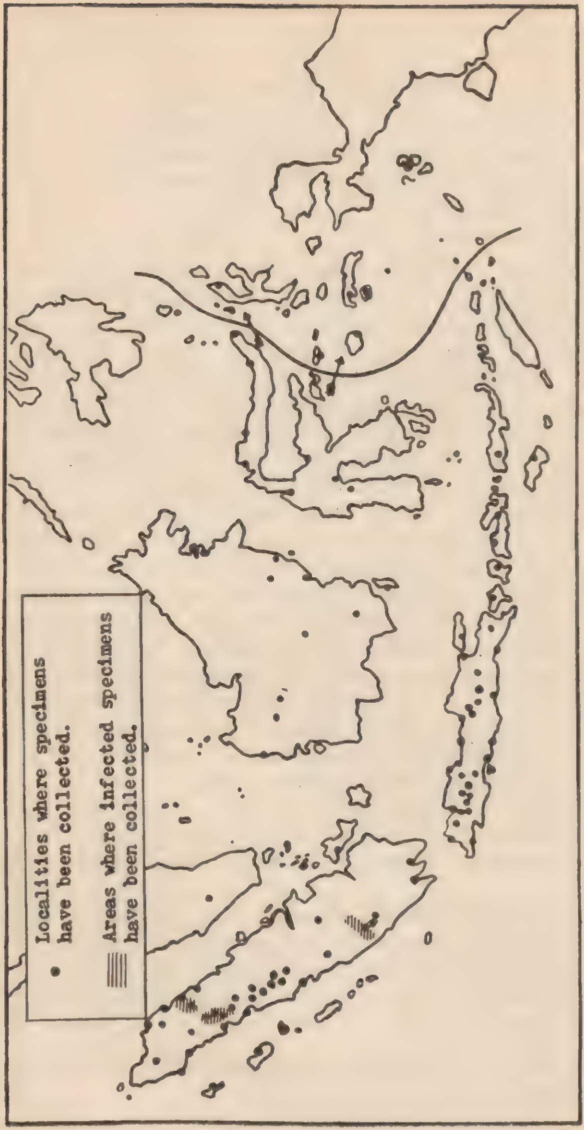
ISLAND OF SUMATRA: Atjeh: Kotaradja (S. V.), Lho Soekon (P.), Lho Seumawe, Belang Pidië, Belang kedjeren, Talang akar, Takengon, Langsa, Meulaboh, Tapatoean, Kota Tjane, Lokop, Bireuen, Singkel (Sp.). **East Sumatra:** Deli Plain, Deli Coast, Kisaran, Karoo Plain, Tandjong Morawa, Bagan Siapiapi (Sp.), Rengat, Moeara Tebo, Laobalang. **West Sumatra:** Sidikalang, Toba Plain, Sibolga, Padang Sidempoean, Angkola djoeloe, Silindoeng Plain, Pahahi Plain, Greater and Lesser Mandailing (S. V.), Soendatar, Rao (P.), Fort de Kock (Sp. Pd.), Fort v. d. Capellen, Singkarak, Solok, Sawah Loento, Naras, Angoli, Moeara laboeh, Padang (Pd.), Pangoeroeran. **South Sumatra:** Ketahoen Plain, Kepahiang, Tjoeroep, Moeara aman, Aerprioekan (Sp.), Lampongs (P.), Kota agoeng.

ISLAND OF BORNEO: Amoentai (Sp.), Sanggau, Singkawang, Barabay, Kendangan, Bandjermasin, Tajan, Tenggarong, Tandjong Redeb, Sankoelirang, Balikpapan, Tarakan, Boven Mahakam, Nangatajap.

ISLAND OF CELEBES: Makassar (V.), Mamoedjoe, Palopo, Pampanoea, Parepare, Barroe, Paloe, Kotamobagoe, Sonder.

OTHER ISLANDS: Nias, Enggano, Riouw (H.), Natoena (Sp.), Banka (Pd.), Billiton, Krakatau, Karimoendjawa, Salajar, Timor (P.), Alor (P.), Ternate (P.).

Unless indicated by the above key specimens were identified only as "*hyrcanus* group."



6. (Appendix C.) *Anopheles kochi.*

Anopheles kochi

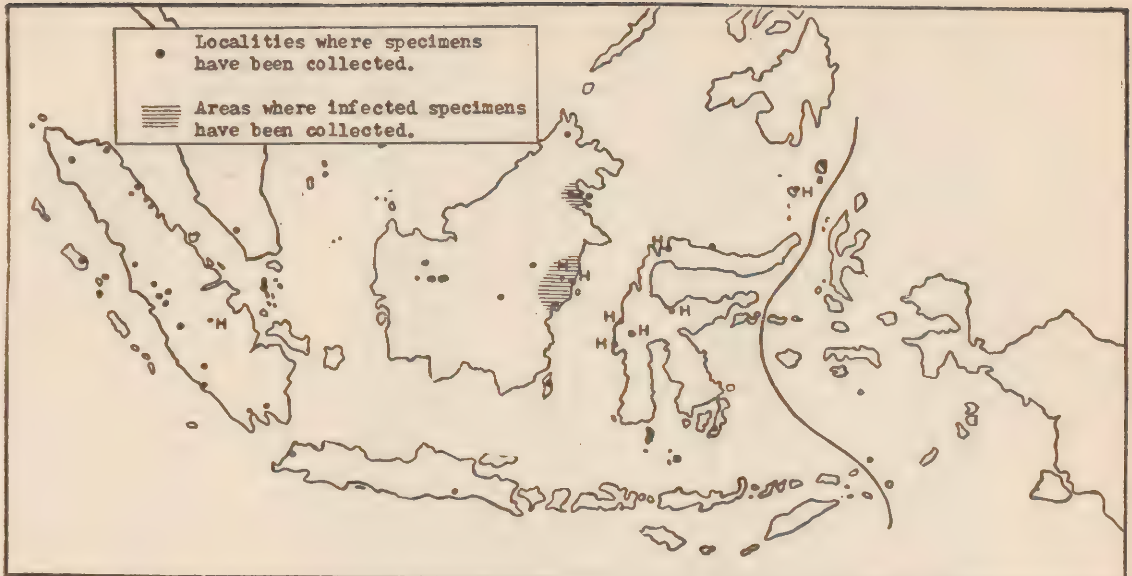
ISLAND OF JAVA: West Java: West Bantam, South Bantam, Serang, Batavia, Tandjong Priok, Buitenzorg, Soekaboemi, Poentjak, Tjimahi, Bandoeng, Bandjar, Tjiheha Plain, Tjikadoe, Tegal wangi, Kepetakan, Cheribon, North Soemedang. **Middle Java:** Tegal, Semarang, Magelang, Ambarawa, Tjilatjap, Noesa kambangan, Gombong, Solo. **East Java:** Madioen Residence, Modojowarjo, South Loemadjang, Bondowoso, Madoera Island.

ISLAND OF SUMATRA: Atjeh: Lho Seumawe, Lho Soekon, Meulaboh, Tapatoean, Lokop, Takengon, Kotatjane, Langsa. **East Sumatra:** Deli-Plain, Deli Coast, Kisaran, Laobalang, Moeara Tebo. **West Sumatra:** Sidikalang, Sibolga, Silindoeng Plain, Pahahi Plain, Padang Sidempoean, Greater Mandailing, Lesser Mandailing, Rao, Soendatar, Fort de Kock, Pajakombo, Padangpandjang, Fort v.d. Capellen, Angoli, Kajoetanam, Naras, Emmahaven, Angkola djoeloe, Moeara laboeh. **South Sumatra:** Doerian, Martapoera, Moeara aman, Ketahoen Plain, Tjoeroep, Aerprioekan, Kepahiang, Lampongs.

ISLAND OF BORNEO: Singkawang, Sanggau, Sintang, Kendangen, Balikpapan, Moeara Tewe, Samarinda, Tenggarong, Tarakan, Tandjong Redeb.

ISLAND OF CELEBES: Paloe, Toli-Toli, Boeol, Menado, Posso, Kotamobagoe, Palopo, Watampone.

OTHER ISLANDS: Nias, Poelau telo, Enggano, Simaloer, Riouw, Billiton, Banka, Batoe Island, Bali, Lombok, Soembawa, Soemba, Flores, Poelau Laoet, Soela Islands, Boeroe, Ambon, Ceram, Halmahera, Ternate, Aroe Islands.



7. (Appendix C.) *Anopheles leucosphyrus leucosphyrus* and *Anopheles leucosphyrus hackeri.*
H.—*Anopheles leucophyrus hackeri*

Anopheles leucosphyrus leucosphyrus and Anopheles leucosphyrus hackeri

H.-*Anopheles leucosphyrus hackeri*

ISLAND OF JAVA: West Java: West Bantam. **South Java:** Tambaksari. **East Java:** South Malang.

ISLAND OF SUMATRA: Atjeh: Langsa, Takengon. **East Sumatra:** Deli Plain, Deli Coast, Tandjong Balai, Kisaran, Moeara Tebo (H.). **West Sumatra:** Greater Mandailing, Soendatar, Kajoetanam, Sawah loento, Moeara laboeh, Angoli, Limau manis. **South Sumatra:** Benkoelen, Moeara aman, Aerprioekan, Doerian, Lampongs.

ISLAND OF BORNEO: Sanggau, Balikpapan, Samarinda (H.), Tenggarong (H.), Tandjong Redeb, Tandjong Selor, Tandjong Palas, Tandjong Djoetar, Moeara Tewe, Upper Mahakam, Sekajam, Tajans Meliau, Tarakan, Sekadau, Nangatajap.

ISLAND OF CELEBES: Madjene (H.), Mamoedjoe (H.), Toradjagebiet (H.), Tolitoli (H.), Paleleh, Posso (H.).

OTHER ISLANDS: Nias, Poelau Laoet, Boeton, Sangihe (H.), Talaud.

8. (Appendix C.) *Anopheles umbrosus.*

Anopheles umbrosus

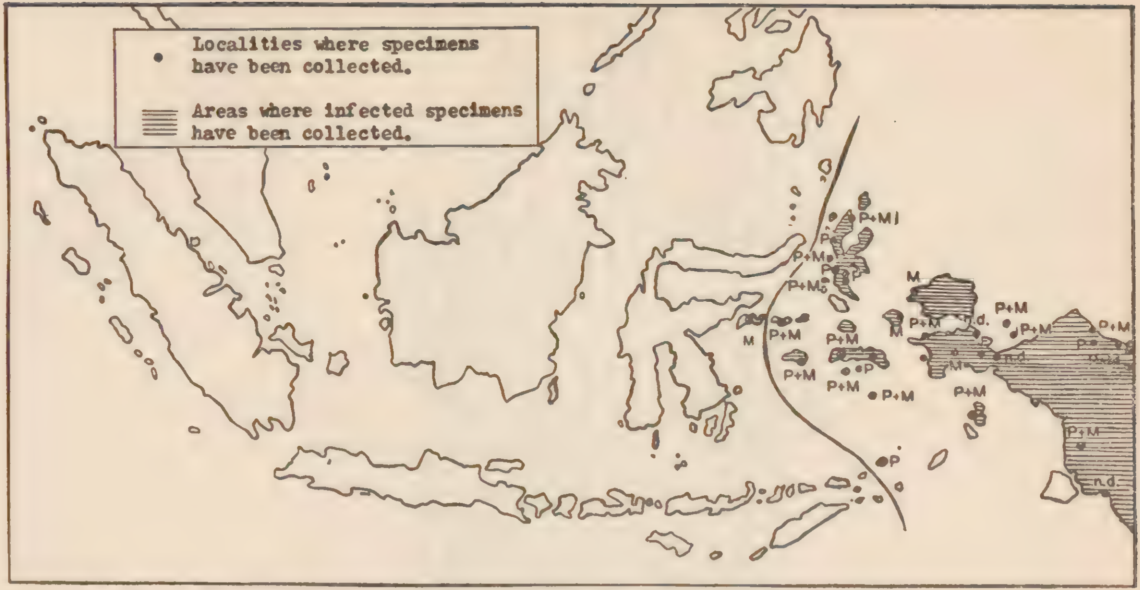
ISLAND OF JAVA: West Java: West Bantam, Batavia, Tandjong Priok, Sindangbarang, Bandjar. **Middle Java:** Noesa kambangan, Tegal, Semarang. **East Java:** Soerabaja, Pasoeroean, Tambaksari.

ISLAND OF SUMATRA: Atjeh: Takengon, Singkel, Meulaboh, Lho Seumawe, Lho Soekon, Kroengradja, Olehleh. **East Sumatra:** Kisaran, Deli Coast, Deli Plain, Kateman, Rengat, Tandjong balai, Moeara Tebo. **West Sumatra:** Sibolga, Padang Sidempoean, Moeara laboeh, Greater Mandailing, Aerprioekan.

ISLAND OF BORNEO: Sanggau, Simpang, Nangatajap, Balikpapan, Koeala Sambodja, Sekadau, Tandjong Redeb, Tenggarong, Tarakan, Upper Mahakam, Tini, Tandjong Selor, Sekajam.

ISLAND OF CELEBES: Madjene, Posso.

OTHER ISLANDS: Nias, Riouw, Banka, Billiton, Natoena, Boeroe.



9. (Appendix C.) *Anopheles punctulatus punctulatus and Anopheles punctulatus moluccensis.*
P.—*A. punctulatus punctulatus* M.—*A. punctulatus moluccensis* n. d.-subspecies not determined

Anopheles punctulatus punctulatus and *Anopheles punctulatus moluccensis*

P.—*A. punctulatus punctulatus* M.—*A. punctulatus moluccensis*
n. d.—subspecies not determined.

NEW GUINEA: Kokas (M.), Kaimana (M.), Fakfak (P. M.), Albatrosbiwak (P. M.), Meer Plain (P. M.), Batavia Biwak (P. M.), Pionier Biwak (P.), Prauw Biwak (M.), Manokwari (n. d.), Merauke (n. d.), Tanah Merah (Digoel) (P. M.), Idora (P.), Schouten Island (P. M.), Sorong (M.), Hollandia (P. M.), Inland from Geelvink Bay (n. d.), Motor Biwak (P. M.).

OTHER ISLANDS: Halmahera: towns of Sidangoli (P.), Tobelo (P. M.), Weda (P. M.), Maidi (P.), Gita (P.); Batjan Archipelago (P. M.), Poelau Salawati (M.), Misool (M.), Poelau Larat (P. M.), Japen Group (P. M.), Ceram (Piroe) (P. M.), Ambon (P. M.), Boeroe (P. M.), Ternate (P. M.), Aroe (P. M.), Soela Island (P. M.), Banggai Island (M.), Banda (P. M.), Saparoea (P.), Damar (P.).

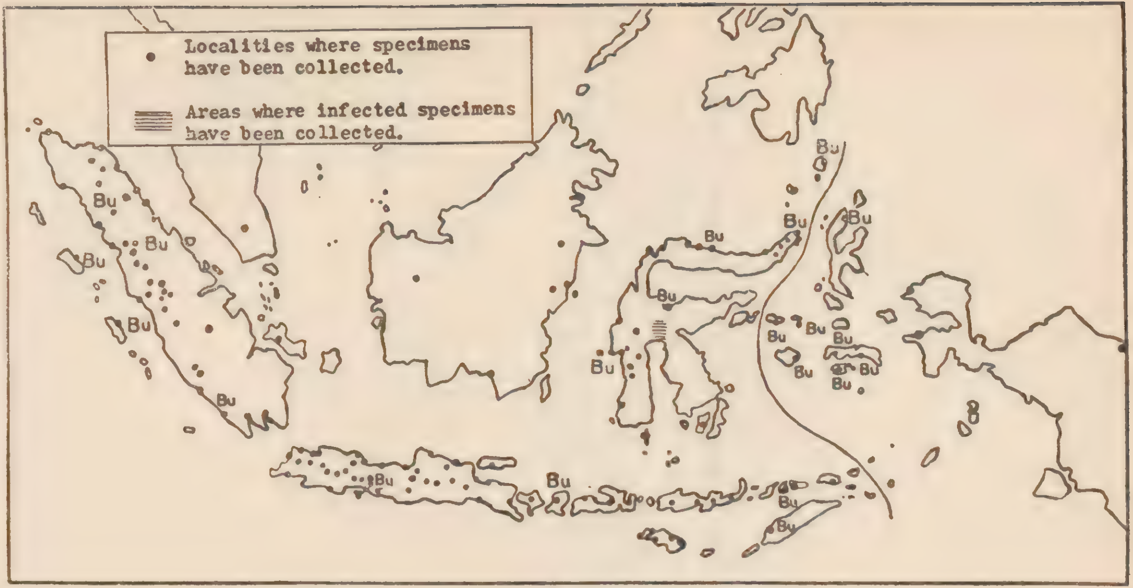
10. (Appendix C.) *Anopheles bancroftii* and *Anopheles pseudobarbirostris.*
B.—*A. bancroftii* Ps.—*A. pseudobarbirostris*

Anopheles bancroftii and *Anopheles pseudobarbirostris*

B.—*A. bancroftii* Ps.—*A. pseudobarbirostris*

NEW GUINEA: Pionierbiwouak (B.), Tanah Merah (B.).

ISLAND OF CELEBES: Makassar (Ps.), Mamoedjoe (Ps.), Madjene (Ps.), Mandar (Ps.), Boeol (Ps.), Kotamobagoe (Ps.), Motoling (Minahassa) (Ps.), Menado (Ps.), Paloe (Ps.).



11. (Appendix C.) *Anopheles barbirostris* and *Anopheles barbumbrosus*.
Bu.—*A. barbumbrosus*

Anopheles barbirostris and *Anopheles barbumbrosus*

Bu—*A. barbumbrosus*

ISLAND OF JAVA: West Java: West Bantam, South Bantam, North Bantam, Hinterland Bantam, Batavia, Buitenzorg, Tandjong Priok, Tjibodas, Poentjak, Tjiteureup, Djampang, Sindangbarang, Soekaboemi, Bandoeng, Tjiheha Plain, North Soemedang, Kepetaken, Cheribon, Tegal wangi, Tjikadoe, Bandjar. **Middle Java:** Tjilatjap, Noesa kambangan, Gombong (Bu.), Babakan, Maos, Banjoemas, Poerworedjo, Margaredjo, Tegal, Semarang, Rembang, Magelang, Djogja, Solo, Ambarawa. **East Java:** Toeban, Soerabaja, Lamongan, Djatirogo, Modjowarno, Wonosari, Madioen, Pasoeroean, Problinggo, South-Loemadjang, Malang, Banjoewangi, Madoera Island.

ISLAND OF SUMATRA: Atjeh: Kotaradja, Takengon, Belang kedjeren, kotatjane, Sigli, Tapatoean, Lho Soekon, Bireuën, Lokop, Langsa, Meulaboh, Lho Seumawe, Singkel, Talang akar. **East Sumatra:** Deli-Plain, Deli-Coast, Kisaran, Moeara Tebo. **West Sumatra:** Sidikalang (Bu.), Sibolga, Silindoeng-Plain, Pahahi Plain, Padang Sidempoean, Greater Mandailing (Bu.), Lesser Mandailing (Bu.), Rao, Soendatar, Fort de Kock, Fort v.d. Capellen, Singkarak, Solok, Sawah loento, Padangpandjang, Naras, Kajoetanam, Moeara laboeh, Angoli, Angkola djoeloe. **South Sumatra:** Benkoelen, Kepahiang, Tjoeroep, Ketahoen Plain, Moeara aman, Kroë (Bu.), Lampongs.

ISLAND OF BORNEO: Tandjong Redeb, Sanggau, Meliau, Samarinda, Tenggarong, Boeloengan, Bandjermasin, Rantau pandjang.

ISLAND OF CELEBES: Makassar, Mamoedjoe, Toradja-Länder, Pampanoea, Parepare, Paloe, Pinrang, Madjene (Bu.), Rapang, Leok, Paleleh (Bu.), Tolitoli, Boeol, Kotamobagoe, Menado (Bu.), Sonder, Motoling, Werot, Likoepang, Palopo, Posso (Bu.).

NEW GUINEA: Kloof Biwouak, Fakfak, Sorong (Bu.), Noeseroe.

OTHER ISLANDS: Nias, Mentawei, Siberoet, Banka, Riouw, Bali, Lombok (Bu.), Moena (Raha), Sanana (Bu.), Boeroe (Bu.), Sangihe, Talaud (Bu.), Salajar, Halmahera (Bu.), Ambon (Bu.), Soela Island (Bu.), Ceram (Bu.), Saparoea (Bu.), Haroekoe (Bu.), Timor (Bu.), Wetar, Kisar, Flores, Pantar (Bu.), Alor, Soembawa, Soemba.

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Appendix D

CHECK LIST AND KEYS FOR THE IDENTIFICATION OF CULICINE MOSQUITOES OF MEDICAL IMPORTANCE.

List of Culicines of Medical Importance in the Netherlands Indies

[*Compiled with some revision from J. Bonne-Wepster and S. L. Brug,* Nederlandsch-Indische Culicinen, *Geneeskundig Tijdschrift voor Nederlandsch-Indië, 77 (9/10), 1937.*]

In 1937, 238 species of culicine mosquitoes were known to occur in the Netherlands Indies. Since that time at least twelve additional species, none of which are of medical importance, have been recorded. The following list contains all species known in 1937 which commonly attack man in addition to some more common species which do not attack man.

Armigeres (*Armigeres*) *obturbans* (Walker), 1860
Armigeres (*Armigeres*) *confusus* Edwards, 1915
Armigeres (*Armigeres*) *denbesteni* Brug, 1925
Armigeres (*Armigeres*) *lacuum* Edwards, 1922
Armigeres (*Armigeres*) *malayi* (Theobald), 1910
Armigeres (*Armigeres*) *moultoni* Edwards, 1914
Aëdes (*Stegomyia*) *albolineatus* (Theobald), 1904
Aëdes (*Stegomyia*) *albopictus* (Skuse), 1894
Aëdes (*Stegomyia*) *annandalei* Theobald, 1910
Aëdes (*Stegomyia*) *aegypti* (Linnaeus), 1762
Aëdes (*Stegomyia*) *scutellaris* (Walker), 1859 (=*variegatus*)
Aëdes (*Ochlerotatus*) *vigilax* (Skuse), 1901
Aëdes (*Aëdimorphus*) *vexans* (Meigen), 1830
Aëdes (*Aëdimorphus*) *alboscutellatus* (Theobald), 1905
Aëdes (*Aëdimorphus*) *caecus* (Theobald), 1901
Aëdes (*Aëdimorphus*) *imprimens* (Walker), 1901
Aëdes (*Banksinella*) *lineatopennis* (Ludlow), 1905
Aëdes (*Aëdes*) *funereus ornatus* (Theobald), 1905
Aëdes (*Finlaya*) *niveus* (Ludlow), 1903
Aëdes (*Finlaya*) *albolateralis* (Theobald), 1908

Aëdes (*Finlaya*) *poicilius* (Theobald), 1903
Aëdeomyia venustipes (Skuse), 1889
Mansonia (*Mansonioides*) *annulata* (Leicester), 1908
Mansonia (*Mansonioides*) *annulifera* (Theobald), 1901
Mansonia (*Mansonioides*) *longipalpis* (van der Wulp), 1892
Mansonia (*Mansonioides*) *indiana* Edwards, 1930
Mansonia (*Mansonioides*) *papuensis* (Taylor), 1914
Mansonia (*Mansonioides*) *uniformis* (Theobald), 1921
Culex (*Lutzia*) *fuscana* Wiedemann, 1820
Culex (*Lutzia*) *halifaxii* Theobald, 1903
Culex (*Culex*) *fatigans* (=*quinquefasciatus*) Wiedemann, 1828
Culex (*Culex*) *mimulus* Edwards, 1915
Culex (*Culex*) *sitiens* Wiedemann, 1828
Culex (*Culex*) *annulirostris* (Theobald), 1905
Culex (*Culex*) *vishnui* (Theobald), 1901
Culex (*Culex*) *tritaeniorhynchus siamensis* Barraud and Christophers, 1931
Culex (*Culex*) *bitaeniorhynchus* Giles, 1901
Culex (*Culex*) *gelidus* Theobald, 1901
Culex (*Culex*) *whitmorei* (Giles), 1904
Culex (*Culex*) *sinensis* Theobald, 1903
Culex (*Culex*) *fuscocephalus* Theobald, 1907

Key to the Determination of the Genera of Netherlands Indies Culicine Mosquitoes

1. (a) Proboscis strongly decurved; V-shaped thickening at the fork of vein 5 ---------- *Megarhinus*
   (b) Proboscis straight or slightly curved; no thickening as described in 1 (a) ---------- 2
2. (a) Tip of proboscis enlarged with very long hairs --- *Harpagomyia*
   (b) Proboscis normal ---------- 3
3. (a) Erect wing scales long and narrow, enlarged at the tip and ending in two points; small mosquities ---------- *Hodgesia*
   (b) Wing scales other than in 3 (a) ---------- 4
4. (a) Erect scales at various places giving the mosquito a moldy apappearance -- *Aëdes* (*Mucidus*) (Part of the *Pardomyia group*)
   (b) No erect scales or only a few limited to the abdomen and legs ---------- 5
5. (a) Dark clouds on wing membrane over cross veins; large orange colored mosquitoes ---- *Aëdes* (*Mucidus*) (*Pardomyia* group)
   (b) No dark clouds as described in 5 (a) ---------- 6

Key to the Determination of the Genera of Netherlands Indies Culicine Mosquitoes—Continued

6. (a) Occiput with shining, metallic, sky-blue scales; moderately large mosquitoes------------------------ *Tripteroides* (In part)
   (b) Such scales not present on the occiput or when they are present, very small mosquitoes-------------------------------- 7
7. (a) Occiput with a metallic area of silver scales; median broad silver stripe of broad scales on the mesonotum-- *Topomyia*
   (b) Mesonotum without median stripe, or if present formed of narrow scales-- 8
8. (a) Abdomen of the female upturned; wing scales very broad ----------------*Mansonia* (*Mansonioides*)
   (b) Abdomen or wing scales not as described in 8 (a)------------- 9
9. (a) Microtrichia on the wings visible as dark points with magnification of 80 diameters----------------------------------- 10
   (b) No microtrichia visible with magnification of 100 diameters; small mosquitoes--------------------------- *Uranotaenia*
10. (a) Metallic scales on the mesonotum and abdomen; postnotum with hair------------------------------------- *Heizmannia*
    (b) Not as described in 10 (a). (*Armigeres flavus* frequently has some hair on the postnotum but lacks the metallic colored scales)--- 11
11. (a) Postspiracular hairs present-- *Aëdes* or *Armigeres* (*Armigeres*). (*Armigeres* (*Armigeres*): Large mosquitoes without markings on the feet, proboscis or dorsal side of the abdomen; the mesonotum has at the most a pale border. *Aëdes:* Members of this genus are usually smaller. Their markings vary considerably.)
    (b) No postpiracular hairs---------------------------------- 12
12. (a) Antennae short, the apical segment obviously not elongate ---------------*Aëdeomyia*
    (b) Antennae normal, the apical segment much longer than the basal segment--- 13
13. (a) Very large mosquitoes with speckled femora and tibiae and unbanded tarsi; a series of at least five hairs on the anterior margin of the mesepimeron---------------- *Culex* (*Lutzia*)
    (b) Obviously not large mosquitoes; not more than two hairs on the anterior margin of the mesepimeron--------------------- 14
14. (a) Few pleural hairs; the uppermost sterno-pleural hairs absent; not more than two pro-epimeral hairs; but with spiracular hairs present-------------------- *Tripteroides* (In part)

Key to the Determination of the Genera of Netherlands Indies Culicine Mosquitoes—Continued

(b) Uppermost sterno-pleural hairs present or more than two proepimeral hairs present; spiracular hairs lacking---------- 15

15. (a) Pulvilli present in the female, most distinct on the fore and middle legs; small in the male------------------- *Culex*

(b) Pulvilli absent or rudimentary-------------------------- 16

16. (a) Fore tarsal segment 1 longer than 2, 3, 4, and 5 together; 4 very short; wings spotted as in the anophelines; female palpus ⅓–½ as long as the proboscis------------- *Orthopodomyia*

(b) Fore tarsal segments not as described in 16 (a). Wings not spotted--- 17

17. (a) Postspiracular area mostly with black scales-------------- --------------*Armigeres* (*Leicesteria*)

(b) Postspiracular area without scales----------------------- 18

18. (a) First forked cell about as long as the petiole--------------- --------------*Ficalbia* (*Mimomyia*)

(b) First forked cell about as long as the petiole------------- 19

19. (a) Large or moderately large mosquitoes; yellowish brown in color; proboscis normal-------------- *Mansonia* (*Coquillettidia*)

(b) Small mosquitoes; principal color neither yellow nor brown; proboscis of male with thickening at apex; proboscis of female with very slight thickening or none at all----------------- --------------Other subgenera of *Ficalbia.*

A Key to the Determination of Culicine Mosquitoes Primarily of Medical Importance

1. (a) Very large mosquitoes with metallic colors, a strongly decurved proboscis, almost angulate, which becomes thinner near the tip; a V-shaped thickening at the margin of the wing between the apices of the branches of vein 5------ Genus *Megarhinus*

(b) No metallic colors; proboscis straight or slightly curved; no "V" between the forks of vein 5-------------------------- 2

2. (a) Wings with light and dark scales------------------------- 3

(b) Wing scales entirely dark, at the most with a few light scales at the base of the costa----------------------------------- 14

3. (a) A large part of vein 1, i. e. at least the basal half, with light scales (in females a large part of vein 5 also). Mesonotum with broad yellow marginal stripes--------------------- --------------*Aëdes* (*Banksinella*) *lineatopennis*

A Key to the Determination of Culicine Mosquitoes Primarily of Medical Importance—Continued

(b) Light areas or specks on the wing veins alternating with dark. Mesonotum not as in 3 (a) ---------------------------- 4

4. (a) Two large pale areas on the costa and vein 1 and a smaller pale area at the apex of the wing --------- *Culex* (*Culex*) *mimulus*

(b) Wings with pale specks sometimes also with small pale areas - 5

5. (a) Wings with pale areas and specks; the pale wing scales are entirely or partly white -- 6

(b) Wings with only pale specks consisting of, at the most, a few scales; the pale wing scales are all yellow or yellowish ----- 7

6. (a) Pale areas and specks on the wing entirely white. Abdomen dorsally with numerous small well-defined white spots on a dark background. Scales on the mesonotum small, and mostly dark ---------------------------- *Aëdes* (*Finlaya*) *poicilius*

(b) Pale areas and yellow specks on the wings. Abdomen indistinctly marked with white, yellow, or light brown scales. Scales on the mesonotum broad, more light than dark ------- -------------- *Aëdeomyia venustipes*

7. (a) Erect wing scales long and narrow. (The erect scales near the apex of the wing may be broader than those near the base.) - 8

(b) All or nearly all of these erect scales are broad. Abdomen of the female short and turned upwards at the caudal end (Genus *Mansonia*, subgenus *Mansonioides*) ------------------- 10

8. (a) A well-defined broad pale band at about the middle of the proboscis. Anterior ⅔—¾ of the mesonotum with paler scales than the rest --------------- *Culex* (*Culex*) *bitaeniorhynchus*

(b) Proboscis and mesonotum otherwise ----------------------- 9

9. (a) Proboscis when viewed from beneath is dark at the base and from there cream-colored for about half its length with the rest dark. Anterior margin of the cream-colored portion is well-defined-- -------------- *Aëdes* (*Ochlerotatus*) *vigilax*

(b) Proboscis when viewed from beneath otherwise. Whenever it is partly cream-colored, this part is not sharply defined anteriorly and often extends almost to the tip -------------------- -------------- *Aëdes* (*Aëdimorphus*) *vexans*

10. (a) Mesonotum with two longitudinal stripes of greenish, pale scales. -------------- *Mansonia* (*Mansonioides*) *uniformis*

(b) Mesonotum otherwise ---------------------------------- 11

A Key to the Determination of Culicine Mosquitoes Primarily of Medical Importance—Continued

11\. (a) Strikingly pale-colored mosquitoes, yellow to light brown. Four silver-white areas on the mesonotum; scutellum with broad, silver-white scales ------ *Mansonia (Mansonioides) annulifera*

(b) Dark mosquitoes, brown to brownish black. Mesonotum other than in 11 (a) Scutellum with small scales---------------12

12\. (a) Mesonotum with an approximate figure-8 of yellow scales. Bands and areas on the legs-------------------------- --------------*Mansonia (Mansonioides) annulata*

(b) Mesonotum without pattern or with areas of pale blue scales. Bands and areas on the legs white-------------------- 13

13\. (a) Very dark mosquitoes. Tibia of foreleg with six well-defined bands--------------- *Mansonia (Mansonioides) longipalpis*

(b) Lighter mosquito; more brownish. Tibia of the foreleg with 10–15 scattered white specks-------------------------- --------------*Mansonia (Mansonioides) indiana*

14\. (a) Erect wing scales broad. Femora with dirty yellow areas----- --------------*Mansonia (Mansonioides) papuensis*

(b) Erect wing scales narrow. Femora other than in 14 (a)---- 15

15\. (a) Proboscis with well-defined light band at about half its length, covering at least one-third of the proboscis-------------- 37

(b) Proboscis without such a band. (Proboscis sometimes pale for more than half its length.)--------------------------- 16

16\. (a) Hind tarsus with pale bands----------------------------- 17

(b) Hind tarsus without pale bands------------------------- 24

17\. (a) Scales of the mesonotum form no well-defined pattern------ 18

(b) Mesonotum with well-defined markings of white scales on a dark background. (Genus *Aëdes*, subgenus *Stegomyia*)--- 20

18\. (a) Femora not speckled---------------------------------- 19

(b) Femora speckled------------------------------------- 9

19\. (a) Integument of the pleura dark brown to almost black. Light bands on the hind tarsus conspicuous; the width of these bands on the first three tarsal segments is greater than the diameter of the segment at the location of the band------- --------------*Aëdes (Aëdimorphus) imprimens*

(b) Integument of the pleura light brown. The pale bands on the hind tarsus not visible to the naked eye; they are not as wide as the diameter of the segment----------------- --------------*Aëdes (Aëdimorphus) caecus*

A Key to the Determination of Culicine Mosquitoes Primarily of Medical Importance—Continued

20. (a) Mesonotum with so-called lyre shaped figure------------- --------------*Aëdes* (*Stegomyia*) *aegypti*
    (b) Mesonotum marked differently than in 20 (a)------------ 21
21. (a) Mesonotum with broad silver-white area anteriorly--------- --------------*Aëdes* (*Stegomyia*) *annandalei*
    (b) Mesonotum with median silver-white stripe for its entire length or the greater part of its length---------------------- 22
22. (a) Hind tarsus with three white bands--------------------- --------------*Aëdes* (*Stegomyia*) *albolineatus*
    (b) Hind tarsus with five white bands. (The fifth tarsal segment which is entirely white is counted as a white band.)------- 23
23. (a) Pleura with white spots----------*Aëdes* (*Stegomyia*) *albopictus*
    (b) Pleura with longitudinal stripes-- *Aëdes* (*Stegomyia*) *scutellaris*
24. (a) Somewhat more than the anterior half of the mesonotum thickly covered with silver-white scales---- *Aëdes* (*Finlaya*) *niveus*
    (b) Similar to 24(a) but with a median broad black stripe on the mesonotum-------------------*Aëdes* (*Finlaya*) *albolateralis*
    (c) Mesonotum without the obvious silver-white markings---- 25
25. (a) Femora with pale specks. Large mosquitoes (Genus *Culex*, subgenus *Lutzia*)------------------------------------ 26
    (b) Femora without spots. Large or smal mosquitoes---------- 27
26. (a) Abdominal tergites entirely dark ol at the most a few apical pale scales on the posteriorabdr ominal segments---------- --------------*Culex* (*Lutzia*) *halifaxii*
    (b) Posterior abdominal tergites with broad yellow apical bands; in the female posterior abdominal tergites frequently entirely yellow--------------------------- *Culex* (*Lutzia*) *fuscana*
27. (a) Abdominal tergites with pale basal bands--*Culex* (*Culex*) *fatigans* (=*quinquefasciatus*.)
    (b) Abdominal tergites with pale bands transversely across the middle of the segments so that these have a dark apex and base. (Mesonotum with pale margin anteriorly and laterally; with dark spot surrounded by light in front of scutellum and a pair of submedian dark areas surrounded by light; a narrow median pale stripe faintly indicated.)------------------- --------------*Aëdes* (*Aëdes*) *funereus ornatus*
    (c) Abdominal tergites without light bands------------------ 28

A Key to the Determination of Culicine Mosquitoes Primarily of Medical Importance—Continued

28. (a) Occiput with many forked scales and many small curved scales; broad flat scales only on the sides ---------------------- 29
    (b) Occiput mainly with broad flat scales at the most a few forked scales near the neck and a few, usually indistinct, narrow curved scales -- 30
29. (a) Scutellum, sparsely covered with narrow, curved, cream-colored scales. Pleura with two parallel, horizontal, unscaled dark stripes, anteriorly the light integument shows between the parallel dark stripes; posteriorly the parallel dark stripes are separated by a stripe of flat white scales ------------ -------------- *Culex* (*Culex*) *fuscocephalus*
    (b) The entire scutellum covered thickly with broad, flat, silver-white scales (a very striking character). Integument of the entire pleura darker with a few areas of silver-white scales -- ---------- *Aëdes* (*Aëdimorphus*) *alboscutellatus*
30. (a) Scutellum with flat broad scales ------------------------- 31
    (b) Scutellum with narrow curved scales (Genus *Aëdes*, subgenus *Aëdes*) --- 40
31. (a) Small mosquitoes. The ventral and lateral edges of the abdomen dark or faintly marked by the presence of dirty yellow scales ----------------- (Genus *Aëdes*, subgenus *Cancaëdes*)
    (b) Large mosquitoes. The ventral and lateral edges of the abdomen with conspicuous markings of white or cream-colored scales (Genus *Armigeres*, subgenus *Armigeres*) ----------- 32
32. (a) Abdominal sternites II–VI entirely covered with white scales - 33
    (b) Abdominal sternites II–VI with black and white bands ------ 34
33. (a) Clypeus with white scales. Abdominal sternite VII entirely white ------------------- *Armigeres* (*Armigeres*) *malayi*
    (b) Clypeus without scales. Abdominal sternite VII black ------ -------------- *Armigeres* (*Armigeres*) *confusus*
34. (a) The white stripe on the outer margin of the hind femur is continuous to the knee joint; abdominal sternites II–VII with a black band --35
    (b) The white stripe on the outer margin of the hind femur does not extend to the knee joint ------------------------------ 36
35. (a) Abdominal sternite VII almost entirely black -------------- -------------- *Armigeres* (*Armigeres*) *denbesteni*
    (b) Abdominal sternite VII almost entirely white --------------- -------------- *Armigeres* (*Armigeres*) *obturbans*

A Key to the Determination of Culicine Mosquitoes Primarily of Medical Importance—Continued

36. (a) Abdominal sternite VII entirely black------------------------------------*Armigeres* (*Armigeres*) *moultoni*
    (b) Abdominal sternite VII with a few subapical or apical white scales------------------- *Armigeres* (*Armigeres*) *lacuum*
37. (a) Abdominal tergites with apical bands. Anterior ⅔ of the mesonotum with cream-colored scales conspicuously contrasting with the darker posterior ⅓ femora speckled.-------------------*Culex* (*Culex*) *sinensis*
    (b) Abdominal tergites with basal bands or areas (at the most small apical band on tergite VII)------------------------------ 38
38. (a) Anterior ⅔ of the mesonotum covered with snow-white scales- 39
    (b) Mesonotum without conspicuous marking although the scales are frequently not all of the same color------------------ 40
39. (a) The snow-white anterior portion of the mesonotum does not have extensions reaching almost to the posterior margin and is therefore separated entirely from the scutellum by a dark area. Basal T-shaped band on the abdominal tergites. Femora not spotted-----------------*Culex* (*Culex*) *gelidus*
    (b) The snow-white anterior part of the mesonotum sends white extensions almost to the posterior margin of the mesonotum. Three-pronged pale basal bands or median basal areas on the abdominal tergites. Femora speckled-------------------------------*Culex* (*Culex*) *whitmorei*
40. (a) Middle femur speckled----------------------------------- 41
    (b) Middle femur not speckled--------------------------------- 42
41. (a) Bases of forked cells approximately equidistant from the base of the wing---------------------- *Culex* (*Culex*) *annulirostris*
    (b) Base of the anterior forked cells at greater distance from the wing--------------------------------- *Culex* (*Culex*) *sitiens*
42. (a) Mesonotum with many cream-colored scales. Base of forked cells approximately equidistant from the base of the wing --------------*Culex* (*Culex*) *vishnui*
    (b) Mesonotum, except the scutellum, with small, dark, narrow scales, no cream-colored scales among them. In the female the base of the anterior forked cell is farther from the wing base than the posterior forked cell. This is sometimes true also in the male although usually the base of the forked cells are equidistant from the base of the wing-------------------------- *Culex* (*Culex*) *tritaeniorhynchus siamensis*

Appendix E

CHECK LIST AND KEYS FOR THE IDENTIFICATION OF TICKS OF THE NETHERLANDS INDIES

Check List of Ticks Known to Occur in the Netherlands Indies

This list is based largely on that of Krijgsman and Ponto (1932) with some new records. In general doubtful records and synonyms due to mistaken identification have been omitted. It must be remembered that the tick fauna of the Netherlands Indies is still not well known and that many more species may subsequently be found.

Genus *Amblyomma*

1. *A. babirussae* Schulze, 1933
   Distribution: Borneo, north Celebes, Minahassa
   Hosts: wild hogs, *Sus babirussa*
2. *A. caelaturum perfectum* Schulze, 1932
   Distribution: Sumatra
   Hosts: reptiles
3. *A. cordiferum* Neumann, 1899
   Distribution: Banda Is. (Molukkas), Krakatau
   Hosts: pythons and other reptiles
4. *A. cyprium* Neumann, 1899
   Distribution: New Guinea
   Hosts: reptiles, wild hogs, cattle, buffalo
5. *A. dammermanni* Warburton, 1927
   Distribution: Java, Kei Islands
   Hosts: unknown

6. *A. follax* Schulze, 1932
   Distribution: Sumatra
   Hosts: (?)
7. *A. feuerborni* Schulze, 1932
   Distribution: East Java
   Hosts: reptiles
8. *A. geomydae* (Cantor), 1847
   Distribution: Pinang Hills, Sumatra; British North Borneo
   Hosts: tortoise (*Geomyda spinosa*)
9. *A. helvolum* Koch, 1844
   Distribution: Java, Borneo (Sarawak), Sumatra, Nordwachter (Java Sea)
   Hosts: *Varanus salvator*, *Mobuia multifasciata*, and other reptiles
10. *A. infestum borneense* Schulze, 1936
    Distribution: Borneo
    Hosts: wild hogs
11. *A. papuana* Hirst, 1914
    Distribution: Southern Dutch New Guinea
    Hosts: unknown
12. *A. robinsoni* Warburton, 1927
    Distribution: Komodo Island
    Hosts: giant lizard, *Varanus komodoensis*
13. *A. sublaeve* Neumann, 1899
    Distribution: Sumatra, Java
    Hosts: *Manis javanica*
14. *A. testudinarium* Koch, 1844
    Distribution: Sarawak, Borneo, Sumatra, Bali, Lombok, Soemba
    Hosts: man, cattle, water buffalo, pigs, wild boar, tiger

Genus *Ixodes*

1. *I. acanthoglossi* Lucas, 1878
   Distribution: New Guinea
   Hosts: anteater
2. *I. cordifer* Neumann, 1908
   Distribution: New Guinea, Celebes, Ambon (*I. cordifer bibex* Schulze, 1935), Waigeu Island
   Hosts: probably various mammals
3. *I. granulatus* Supino, 1897
   Distribution: Java, Sumatra
   Hosts: various rodents

4. *I. holocyclus* Neumann, 1899
   Distribution: Kei Islands
   Hosts: man (in Australia), dog, sheep, cattle, other mammals, domestic fowl
5. *I.* (*Endopapiger*) *luxuriosus* Schulze, 1935
   Distribution: North New Guinea
   Hosts: rodents
6. *I. praematurus* Schulze, 1935
   Distribution: Timor
   Hosts: small birds
7. *I. priscicollaris* Schulze, 1932
   Distribution: New Guinea
   Hosts: flying phalangers
8. *I. spinicoxalis* Neumann, 1899
   Distribution: Sumatra, West Java
   Hosts: small carnivores, rodents, shrews
9. *I. steini* Schulze, 1933
   Distribution: New Guinea
   Hosts: small marsupial mammals
10. *I. trimaculatus* Lucas, 1879
    Distribution: New Guinea
    Hosts: lizard, *Varanus chlorostigma*
11. *I. kopsteini* Oudemans, 1925
    Distribution: Ambon
    Hosts: ?

Genus *Dermacentor*

1. *D. atrosignatus* Neumann, 1901
   Distribution: New Guinea, Australia
   Hosts: man, monkeys
2. *D. auratus* Supino, 1897
   Distribution: Java, Riouw Archipelago, Soela Islands, Sumatra
   Hosts: deer, wild boar, bears

Genus *Aponomma*

1. *A. draconis* Warburton, 1933
   Distribution: Komodo Island
   Hosts: *Uranus komodoensis*
2. *A. gervaisi* (Lucas), 1847
   Distribution: Java, Sumatra, New Guinea
   Hosts: reptiles

3. *A. lucasi.* Warburton, 1910
   Distribution: Java
   Hosts: snakes (*Coluberide*)
4. *A. oudemansi* Neuman, 1910
   Distribution: New Guinea
   Hosts: anteaters
5. *A. trabeatum* Schulze, 1933
   Distribution: North New Guinea
   Hosts: lizards
6. *A. trimaculatum* Lucas, 1878
   Distribution: Sumatra, New Guinea
   Hosts: snakes, horses, cattle

Genus *Haemaphysalis*

1. *H. bispinosa* Neumann, 1897
   Distribution: Borneo (Sarawak), North Sumatra, West Java, East Soembawa, South and East Celebes, Kariman-Djawa
   Hosts: many large mammals, moles, domestic fowl
2. *H. calvus* Nuttall and Warburton, 1915
   Distribution: British North Borneo
   Hosts: water buffalo (*Bos bubalis*)
3. *H. cornigera* Neumann, 1897
   Distribution: British Borneo, Sumatra, Java, Borneo, East Soembawa, Kariman-Djawa
   Hosts: large mammals.
4. *H. leachi* (Audouin), 1827
   Distribution: Sumatra, West Java, Borneo (Sarawak)
   Hosts: large mammals.
5. *H. hystricis* Supino, 1897
   Distribution: Sumatra, Borneo (Sarawak), Celebes, Riouw Archipelago
   Hosts: large mammals.
6. *H. monospinosa* Krijgsman and Ponto, 1932
   Distribution: Riouw Archipelago—east of Sumatra
   Hosts: dwarf deer, *Tragulus kanchil.*
7. *H. novae-guineae* Krijgsman and Ponto, 1932
   Distribution: Merauke (Southern New Guinea)
   Hosts: wild hog.
8. *H. papuana* Thorell, 1882
   Distribution: Java, Borneo, Sumatra, New Guinea, Sanghii, Ambon, Soembawa, Soela, Halmahera, Alor, Saparoea
   Hosts: large mammals.

9. *H. toxopei* Warburton, 1927
   Distribution: Boeroe (Molukkas)
   Hosts: bats.
10. *H. wellington.* Nuttall and Warburton, 1908
   Distribution: Borneo (Sarawak), South Sumatra, Java, New Guinea
   Hosts: water buffalo, dog.

Genus *Rhipicelphalus*

1. *R. haemaphysaloides* Supino, 1897
   Distribution: Sumatra, Java, Roti, Madoera, Soembawa, Celebes, Soemba, Sawoe, Timor, Alor, Southeast Borneo
   Hosts: man, many other large mammals, rodents.
2. R. *intermedius* Neumann
   Distribution: Sumatra
   Hosts: *Tarsius spectrum.*
3. *R. sanguineus* (Latreille), 1804
   Distribution: world-wide distribution, everywhere where dogs have penetrated. Java, Soemba, Sumatra, Madoera, Timor, Alor, Ambon, Saparoea
   Hosts: man, dog, cattle, buffalo, goats, and many other mammals.

Genus *Boophilus*

1. *B. annulatus australis.*
   Distribution: widely distributed throughout the Netherlands Indies: Sumatra, Java, Borneo, Celebes, Boetoeng, Soela, Lombok, Timor, Tanimbar Islands, New Guinea, west Ceram, Ambon, Madoera and all of the innumerable little islands of the archipelago where cattle are found.
   Hosts: cattle, buffalo, horse, goat, deer, *Bos sundaicus.*
   NOTE: The Netherlands Indies specimens have been arranged into the three species listed below.
2. *B.* (*Uroboophilus*) *rotundiscutatus* Minning, 1934
   Distribution: Celebes, Borneo, Sumatra, Java, Soemba, Timor, Ambon, Bali.
   Hosts: cattle, buffalo.
3. *B.* (*Uroboophilus*) *longiscutatus* Minning, 1934
   Distribution: New Guinea, Soela Island
   Hosts: cattle.
4. *B.* (*Uroboophilus*) *krijgsmani* Minning, 1934
   Distribution: Sumatra, Soela, Bali, New Guinea, Soemba, Celebes, Borneo
   Hosts: cattle.

Genus *Hyalomma*

1. *H. aegyptium* (Linnaeus), 1758
   Distribution: West Java
   Hosts: cattle.
   NOTE: Introduced into Java from British India with imported cattle. Has not spread and may have died out.

Genus *Argas*

1. *A. persicus* Oken, 1812.
   Distribution: West Java, Soemba—also world-wide, wherever chickens are raised.
   Hosts: birds (domestic fowl), mammals, occasionally man.

Keys to the Identification of the Ticks of the Netherlands Indies

These keys are translations, with some revision, of the keys of Krijgsman and Ponto (1932) which are the only ones available for this area. Since the time when these keys were compiled several additional species have been found (see check list), a fact to be borne in mind when the keys are used. However in view of the amount of time devoted by Krijgsman and Ponto to the study of the Netherlands Indies ticks it can be assumed that their keys deal with all of the more common species.

Ixodoidea

a. Capitulum ventral, not visible dorsally. Peritremes at the level of the third intercoxal space.............. *Argasidae* (*A. persicus*)
b. Capitulum on the anterior margin of the body. Peritremes posterior to the 4th pair of legs.............................. *Ixodidae*

Keys to the Identification of the Ticks of the Netherlands Indies—Continued

Ixodidae

Anal groove lies anterior to the anus, its arms bend posteriorly. *Ixodes*
Anal groove absent or lying posterior to the anus with arms bending anteriorly ---------- 1
1. Anal groove and festoons present ---------- 2
   Anal groove and festoons absent ---------- *Boophilus* (*B. annulatus*)
2. Basis capituli (from dorsal view) hexagonal ---------- *Rhipicephalus*
   Basis capituli with 3, 4, or 5 sides ---------- 3
3. Palpi long. (Second segment much longer than wide.) ---------- 4
   Palpi short. (Second segment not as long or only slightly longer than wide.) ---------- 6
4. Eyes present ---------- 5
   Eyes absent ---------- *Aponomma*
5. 2nd palpal segment much longer than 3rd ---------- *Amblyomma*
   2nd palpal segment about as long as 3rd ---------- *Hyalomma*
6. Scutum ornate, eyes present ---------- *Dermacentor* (*D. auratus*)
   Scutum not ornate, eyes absent ---------- *Haemaphysalis*

Rhipicephalus

Males

a. Innermost pair of anal plates elongated, pear-shaped with only slightly concave inner margins ---------- *R. sanguineus*
b. Innermost pair of anal plates sickle-shaped with strongly concave inner margins ---------- *R. haemaphysaloides*

Females

a. Scutum clearly longer than broad with fine punctuations, body moderately covered with hair ---------- *R. sanguineus*
b. Scutum about as long as broad and covered with coarser punctuations, body densely covered with hair ---------- *R. haemaphysaloides*

Haemaphysalis

Males

Coxa IV with two long spurs ---------- *H. cornigera*
Coxa IV with one short spur ---------- 1
1. Scutum almost twice as long as wide ---------- 2
   Scutum shorter ---------- 3

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Keys to the Indentification of the Ticks of the Netherlands Indies—Continued

Haemaphysalis—Continued

2. The dorsal posterior margin of the third palpal segment with a spine ---------------- *H. novae-guinea**
   The dorsal posterior margin of the 3rd palpal segment without a spine ---------------------- *H. leachi*
3. Marginal grooves well developed, long------------------------ 5
   Marginal grooves poorly developed, visible only near the peritremes- 4
   Marginal grooves absent------------------------------------ 6
4. Cornua weakly developed. Small spur on ventral side of 3rd palpal segment-- *H. papuana*
   Cornua well developed, very large spur on ventral side of 3rd palpal segment------------------------------------ *H. monospinosa*
5. Cornua well developed, cervical groove poorly developed (short and shallow)--------------------------------------- *H. bispinosa*
   Cornua poorly developed, cervical groove well developed (long and deep)--- *H. wellington*
6. Festoons on dorsal side longer than wide. Scutum with dots mixed with larger spots---------------------------------- *H. hystricis*
   Festoons on dorsal side wider than long. Scutum with many fine dots only--- *H. toxopei*

Females

The cervical groove reaches the posterior margin of the scutum------ -------------------- *H. toxopei*
The cervical groove does not reach the posterior margin of the scutum-- 1

1. The third palpal segment with spine on dorsal side -------------- 2
   Third palpal segment without spine on dorsal side--------------- 3
2. Cornua absent----------------------------------- *H. wellington*
   Cornua present--- 4
3. Second palpal segment bears dorsally on the lateral surface a broad 3-sided protrusion which points posteriorly----------- *H. leachi*
   No such protrusion--------------------------------------- 5
4. Peritremes approximately round, cornua short and blunt, scutum oval in shape. Cervical grooves converge first, then usually bend abruptly outwardly---------------------------- *H. bispinosa*

* *H. novae-guinea* of Krijgsman and Ponto, 1932 is preoccupied by *H. novaeguinae* of Hirst, 1914.

Keys to the Identification of the Ticks of the Netherlands Indies—Continued

Haemaphysalis—Continued

Peritremes pear-shaped, cornua well-developed, scutum round. Cervical grooves form deep grooves at distance from anterior margin of the scutum and then become shallow and bend toward the margin -- *H. hystricis*

5. The second palpal segment with a well-developed lateral protuberance; the scutum has a feather-like margin --------- *H. cornigera*
   The second palpal segment without a well developed lateral protuberance; margin of scutum not feather-like ---------- *H. papuana*

Amblyomma

Males

Festoons on dorsal side not visible -------------------- *H. papuana*
Festoons on dorsal side easily visible ---------------------------- 1

1. Basis capituli from dorsal view triangular. Legs with shiny green flecks dorsally at the joints ------------------------ *A. robinsoni*
   Basis capituli from dorsal view quadrangular ------------------ 2
2. Scutum ornamented -- 3
   Scutum not ornamented ----------------------------- *A. sublaeve*
3. Second palpal segment twice as long as third --------------------- 4
   Second palpal segment less than twice as long as third ---- *A. cyprium*
4. Scutum no longer than 3 mm., ornate with seven clearly marked pale flecks one of which lies in the middle ---------------- *A. helvolum*
   Scutum 5 mm. long or longer, ornated differently ----------- 5
5. Scutum gold-yellow with dark brown ornaments. Legs light brown with pale rings at the joints. Coxa I with two spurs of unequal length ----------------------------------- *A. testudinarium*
   Scutum dark brown with pale ornaments. Legs dark brown and dorsally with a few pale flecks ------------------- *A. caelaturum*

Females

Scutum with pale flecks ------------------------------------ 1
Scutum without pale flecks ---------------------------------- 7

1. Scutum with only three distinct pale flecks on each side ----------- 2
   Scutum otherwise -- 4
2. Second palpal segment three times as long as third, basis capituli forms an approximate trapezoid (with its base anterior) - *A. caelaturum*
   Second palpal segment is less than three times as long as the third, basis capituli different than in *caelaturum* ---------------------- 3

Keys to the Identification of the Ticks of the Netherlands Indies—Continued

Amblyomma—Continued

3. Coxa II with two spurs, peritremes in shape of equilateral triangles ------------------- *A. robinsoni*
   Coxa II with a spur, peritremes comma-shaped-------- *A. helvolum*
4. Basis capituli clearly triangular--------------------- *A. geomydae*
   Basis capituli otherwise---------------------------------- 5
5. Marginal grooves developed-------------------- *A. testudinarium*
   Marginal grooves undeveloped or absent---------------------- 6
6. Scutum triangular, posterior angle acute, hair long------- *A. cyprium*
   Scutum more heart-shaped, posterior angle blunt, hair short-------- ---------------- *A. dammermani*
7. All coxae have two spurs each---------------------- *A. papuana*
   Not all coxae have two spurs each---------------------------- 8
8. Coxa I and II each with two well developed spurs, innermost spur on Coxa III reduced to a small knoblet, marginal grooves absent-- ----------------- *A. cordiferum*
   Coxa I with two broad flat blunt spurs, the other coxae each with one broad flat blunt spur; marginal grooves present-------- *A. sublaeve*

Ixodes

Males

Basis capituli quadrangular------------------------ *I. holocyclus*
Basis capituli five sided------------------------------------- 1

1. Posterior margin of Coxa II with two spurs--------------- *I. cordifer*
   Posterior margin of Coxa III with one spur---------- *I. granulatus*

Females

Coxa I with a very long spine on the inside of the posterior margin ----------------- *I. spinicoxalis*
Coxa I with a weak spine on the inside of the posterior margin---- 1

1. Arms of anal groove converge considerably, legs yellow-red------- ------------------ *I. holocyclus*
   Arms of anal groove diverge, legs dark brown-------- *I. granulatus*

Appendix F

TABLES FOR THE IDENTIFICATION OF TROMBICULID LARVAE OF THE NETHERLANDS INDIES

Larvae of Trombiculid Mites

The tables in this appendix have been adapted without modification from Walch (1922, 1927) and are the most complete descriptions available in the literature. Actually because of lack of specimens in this country there is no way of ascertaining their accuracy and usefulness. It should be remembered that in so far as can be ascertained in none of the species known to occur in the Netherlands Indies have the adult mites been found. Furthermore it is quite likely that hitherto undescribed species may be encountered which will complicate the use of the tables. Nevertheless it appears that the material compiled in these tables should at least serve as a starting point in the identification of these larvae.

SPECIFIC DETERMINATION OF TROMBICULAE OF THE NETHERLANDS INDIES

Points for differentiation	*T. muris*	*T. oudemansi* n. sp.	*T. acuscutellaris*
Color:			
Macroscopical aspect	Yellowish-white	Yellowish-white, sometimes orange.	Deep red.
Color of body hairs	Colorless	Colorless	Red.
Scutum:			
Form			
Length (in micra)	36	50	68.
Width (in micra)	54	72	77.
Relative position of sensory hairs and posterior lateral hairs.	Posterior lateral hairs 10 micra behind the sensory hairs.	Posterior lateral hairs 12 micra behind the sensory hairs.	Posterior lateral hairs 9 micra behind the sensory hairs.
Length of anterior lateral hair (in micra).	17	27	42.
Length of sensory hairs (in micra)	24	39	77.
Morphology of sensory hairs (measurements in micra).	Clubshaped; with distinct hairs. Length of stem 7; length of body 17; width of body 6.	Clubshaped. Oblong. Hairs very distinct; length of stem 8; length of body 31; width of body 9.	Long and slender; distal part with 2–3 spines and 8–9 hairs nearly all on external side; ratio about 2:3.
Eyes:			
Size: Refractiveness	Probably anterior eye>posterior eye.	Anterior eye>posterior eye. Anterior eye more refractive than posterior one.	Anterior eye much bigger than the posterior one.
Hairs of trunk:			
Number of hairs (average):			
Ventral surface	24	38 + 8 on posterior border of body.	19.
Dorsal surface	32 or 34	30	24.

Situation of dorsal hairs in transverse rows.	10, 6, 6, 4, 4, 2 (10, 6, 6, 6, 4, 2)	8, 8, 8, 4, 2 (2, 6, 6, 2, 6, 6, 2)	8, 6, 6, 4, 2.
Length of dorsal hair (average) (in micra).	20	22	60.
Number of lateral branches of dorsal hairs (first and second row):			
Convex side (in each of both rows).	3–6	2–5	10–13.
Concave side (in each of both rows).	2–3	2–3	6–7.
Number of hairs on coxae:			
First pair			
Second pair			
Third pair			
Palp:			
Number and kind of hairs:			
Trochantero-femur	1 plain hair	1 plain hair	1 feathered hair.
Genu	1 hair with 1 branch	1 feathered hair	1 feathered hair.
Tibia	3 plain hairs	3 feathered hairs (only 1 really plumose).	1 feathered hair, 2 plain hairs.
Tarsus (appendiculum)	4 feathered hairs (3 with only 1 branch), 3 plain hairs, 1 seta.	6 feathered (1 very conspicuous), 1 plain hair, 1 seta.	8 feathered hairs (one very conspicuous), 1 seta.
Number of prongs of claw	2	2	3.
Chelicerae: Length of hook (in micra).	20	32	43.
Galea: Hair	Unfeathered	Unfeathered	Unfeathered.
Host: Kind of host	Rat (Deli)	Rat (Deli)	Rat (Deli).

SPECIFIC DETERMINATION OF TROMBICULAE OF THE NETHERLANDS INDIES—Continued

Points for differentiation	*T. schuffneri*	*T. deliensis*	*T. pseudo-akamushi*
Color:			
Macroscopical aspect	Red	Orange-red, sometimes yellowish-white.	Deep red.
Color of body hairs	Colorless	Colorless	Red.
Scutum:			
Form			Medial hair on the same level as anterior lateral hairs.
Length (in micra)	55	37	60.
Width (in micra)	84	74	99.
Relative position of sensory hairs and posterior lateral hairs.	On one line	Posterior lateral hairs 4 micra behind the sensory hairs.	Posterior lateral hairs 10 micra behind the sensory hairs.
Length of anterior lateral hair (in micra).	61	39	46.
Length of sensory hairs (in micra).	29	61	60.
Morphology of sensory hairs (measurements in micra).	Clubshaped with very minute hairs; length of stem 7; length of body 27; width of body 15.	Long and slender; distal part within total 9 hairs; ratio of proximal (naked) and distal part about 1:1.	Long and slender; distal part with 6–9 hairs on the external side; ratio about 1:1.
Eyes:			
Size: Refractiveness	Anterior eye>posterior eye	Anterior eye>posterior eye. Sometimes the anterior eye is more refractive than the posterior one.	Anterior eye>posterior eye.
Hairs of trunk:			
Number of hairs (average):			

Dorsal surface	42	28	20.
Ventral surface	30	21	12 (13).
Situation of dorsal hairs in transverse rows.	10, 10, 8, 8, 6 (with slight variation).	10, 6, 6, 4, 2	8, 6, 4, 2 (8, 6, 2, 4).
Length of dorsal hair (average) (in micra).	30	42 (large individual variation)	44.
Number of lateral branches of dorsal hairs (first and second row):			
Convex side (in each of both rows).	6–8	9–12	7–8.
Concave side (in each of both rows).	2–4	3–6	3–5.
Number of hairs on coxae:			
First pair			
Second pair			
Third pair			
Palp:			
Number and kind of hairs:			
Trochantero-femur	1 feathered hair	1 plain hair	1 feathered hair.
Genu	1 feathered hair	1 plain hair	1 plain hair.
Tibia	1 feathered hair, 2 plain hairs	1 feathered, 2 plain hairs (1 of the latter on ventral surface).	1 feathered, 2 plain hairs.
Tarsus (appendiculum)	7 feathered, 2 plain hairs	7 feathered hairs, 1 rod shaped seta.	7 feathered (one of them very conspicuous), 1 plain hair, 1 seta.
Number of prongs of claw	2	2 (3)	2.
Chelicerae: Length of hook (in micra).	53	23	42.
Galea: Hair	Unfeathered	Feathered	Unfeathered.
Host: Kind of host	Man (Deli)	Rat; man (Deli)	Swine; man; fowl (Deli).

SPECIFIC DETERMINATION OF TROMBICULAE OF THE NETHERLANDS INDIES—Continued

Points for differentiation	*T. pseudo-schuffneri*	*T. glabrum*	*T. globulare*
Color:			
Macroscopical aspect			
Color of body hairs			
Scutum:			
Form	Pentagonal with anterior margin; longer than lateral margin.	The 2 halves of the posterior margin meet one another at a sharp angle.	
Length (in micra)	49	49	34.
Width (in micra)	76	50	61.
Relative position of sensory hairs and posterior lateral hairs.	Posterior lateral hairs 6 micra in front of sensory hairs.	Posterior lateral hairs 17 micra behind the sensory hairs.	Posterior lateral hairs 3 micra in front of sensory hairs.
Length of anterior lateral hairs (in micra).	67	28	43.
Length of sensory hairs (in micra)	36	29	25.
Morphology of sensory hairs (measurements in micra).	Clubshaped with very minute hairs; length of stem 10; length of body 26, width of body 13.	Clubshaped, with distinct hairs. Length of stem 4; length of body 25, width of body 13.	Clubshaped with very minute hairs. Length of stem 6, length of body 19, width of body 15. Pseudostigmata very close to each other.
Eyes:			
Size: Refractiveness	Anterior eye>posterior one. Anterior eye more refractive than posterior one.	Probably only 1 eye present, perhaps none.	Anterior eye>posterior one Anterior eye more refractive than posterior one.
Hairs of trunk:			
Number of hairs (average): Dorsal surface.	32+2 on posterior	32+2 on posterior	41–38+7 on posterior.

Situation of dorsal hairs in transverse rows.	12, 6, 6, 4, 4 (with slight individual variation).	8, 6, 6, 6, 4, 2	With individual variation. eg. 10, 6, 6, 8, 6, 2.
Length of dorsal hair (on an average) (in micra).	40	34	33.
Side hairs of dorsal hairs	Minute	Distinct	Very distinct.
Number of lateral branches of dorsal hairs (first and second row:			
Convex side (in each of both rows).	7–9	6–8	9–12.
Concave side (in each of both rows).	3–4	3–4	7–8.
Number of hairs on coxae:			
First pair	1	1	1.
Second pair	1	1	1.
Third pair	1	3	2.
Palp:			
Number and kind of hairs:			
Trochantero-femur	1 feathered hair	1 plain hair	1 feathered hair.
Genu	1 plain hair	1 (long) plain hair	1 feathered hair.
Tibia	1 feathered, 2 plain hairs	3 plain hairs	3 feathered hair.
Tarsus (appendiculum)	6 feathered (one of them very conspicuous), 2 plain hairs.	5 feathered hairs, 1 seta	5–6 feathered hairs (1 of them very conspicuous), 1 plain hair?
Number of prongs of claw	3	3	2.
Chelicerae: Length of hook (in micra)	32	23	30.
Galea: Hair	Unfeathered	Unfeathered	Slightly feathered.
Host: Kinds of host	Man, rat (Lampong districts, South Sumatra).	Rat (Lampong districts)	Rat (South Celebes).

SPECIFIC DETERMINATION OF TROMBICULAE OF THE NETHERLANDS INDIES—Continued

Points for differentiation	*T. densipiliata*	*T. vandersandei*	*T. wichmanni*
Color:			
Macroscopical aspect	Deep red	Red	Red.
Color of body hairs	Red		
Scutum:			
Form		Nearly hexagonal. The anterior margin is the longest one; posterior border slightly curved inward.	Resembles that of *T. pseudoakam.*, only the posterior margin is curved inward in middle.
Length (in micra)	51		
Width (in micra)	81		
Relative position of sensory hairs and posterior lateral hairs.	Posterior lateral hairs 5 micra behind the sensory hairs.	On 1 line	Posterior lateral hairs behind the sensory hairs.
Length of anterior lateral hair (in micra).	51		
Length of sensory hairs (in micra)	45		
Morphology of sensory hairs (measurements in micra).	Long and slender; distal part with 1 spine and three rows of hairs (4, 5, 5), ratio about 4: 3.	Clubshaped; with very minute hairs.	Long and slender; distal part with about 5 hairs.
Eyes:			
Size: Refractiveness	Anterior eye much bigger than the posterior one and much more refractive.	Anterior eye > posterior eye	Anterior eye > posterior eye.
Hairs of trunk:			
Number of hairs (average):			
Dorsal surface	58	50	24.

Ventral surface	35	42	14.
Situation of dorsal hairs in transverse rows.	10, 9, 12, 11, 6, 4, 4, 2	12, 10, 10, 10, 8	6, 6, 6, 6 (newly hatched larvae).
Length of dorsal hair (on an average) (in micra).	50		
Number of lateral branches of dorsal hairs (first and second row)			
Convex side (in each of both rows).	7–9		
Concave side (in each of both rows).	3–5		
Number of hairs on coxae:			
First pair			
Second pair			
Third pair			
Palp:			
Number and kind of hairs:			
Trochantero-femur	1 feathered hair	1 feathered hair	1 feathered hair.
Genu	1 feathered hair	1 feathered hair	1 plain hair.
Tibia	1 hair with 1 branch, 2 plain hairs.	1 feathered hair, 1 plain hair	1 feathered, 2 plain hairs.
Tarsus (appendiculum)	7 feathered hairs (1 very conspicuous), 1 seta.	4 feathered, 3 plain hairs	5 feathered (1 very conspicuous), 2 plain hairs (1 of them is short).
Number of prongs of claw	3	2	2.
Chelicerae: Length of hook (in micra).	44		
Galea: Hair	Unfeathered	Unfeathered	Unfeathered.
Host: Kind of host	? (Found on the earth)	Man; New Guinea, also in the forest.	Man, Celebes; Goura spec. New Guinea.

SPECIFIC DETERMINATION OF TROMBICULAE OF THE NETHERLANDS INDIES—Continued

Points for differentiation	*Leeuwenhoekia australiensis*	*Schöngastia salmi*
Color:		
Macroscopical aspect		
Color of body hairs		
Scutum:		
Form	In the middle of the anterior margin there is a forwardedly directed, elongated process (length 27 micra).	Posterior part slightly corrugated.
Length (in micra)	63	60.
Width (in micra)	86	105.
Relative position of sensory hairs and posterior lateral hairs.	Posterior lateral hairs 4 micra in front of sensory hairs.	Sensory hairs half way the line connecting the anterior and the one uniting the posterior lateral hairs.
Length of anterior lateral hairs (in micra)	53	Equal to the distance between the two anterior lateral hairs.
Length of sensory hairs (in micra)	61	
Morphology of sensory hairs (measurements in micra).	Long and slender distal part with 4 or 5 side-hairs, ratio of proximal (naked) and distal part about 2:3.	Clubshaped (resembling those of *T. vandersandei*, *T. schuffneri*, etc.) with very minute hairs. *Pseuodostigmata* widely apart, hidden in a body falx.
Eyes:		
Size: Refractiveness	Anterior eye>posterior one	Anterior eye much larger than posterior one, also much more refractive.
Hairs of trunk:		
Number of hairs (average): Dorsal surface.	64+6 on border	116+12 on border.

Situation of dorsal hairs in transverse rows.	8, 14, 8, 10, 8, 6, 4	14, 12, 10, 10, 10, 10, 10, 10, 10, 10, 10.
Length of dorsal hair (on an average) (in micra).	48	
Side hairs of dorsal hairs	Short	
Number of laterial branches of dorsal hairs (first and second row):		
Convex side (in each of both rows)	10–12	
Concave side (in each of both rows)	2–8	
Number of hairs on coxae:		
First pair	2	1.
Second pair	1	1.
Third pair	1	3.
Palp:		
Number and kind of hairs:		
Trochantero-femur	1 feathered	
Genu	1 feathered	
Tibia	2 feathered hairs and 1 plain hair or 3 feathered hairs.	
Tarsus (appendiculum)	7 feathered hairs, 1 plain hair	
Number of prongs of claw	3	3.
Chelicerae: Length of hook (in micra)	53	
Galea: Hair	With minute sidehairs	
Host: Kinds of host	Rat (South Celebes)	Unknown (Java).

NUMBER AND KINDS OF HAIRS ON THE LEGS OF TROMBICULIDS OF THE NETHERLANDS INDIES

Kinds of hairs	Name of species															
	T. schüffneri				*T. deliensis*				*T. pseudoakamushi*				*T. muris*			
	Feathered hairs	Bristles	Rod-shaped setae	Spines	Feathered hairs	Bristles	Rod-shaped setae	Spines	Feathered hairs	Bristles	Rod-shaped setae	Spines	Feathered hairs	Bristles	Rod-shaped setae	Spines
First leg:																
1 segment	1	------	------	------	1	------	------	------	1	------	------	------	1	------	------	------
2 segment	1	------	------	------	1	------	------	------	1	------	------	------	1	------	------	------
3 segment	5	------	------	------	5	------	------	------	5	------	------	------	5 or 4+	1?	------	------
4 segment	4	3	------	1	4	2	------	1	4	3	------	1	4	3	------	1
5 segment	8	2	------	1	8	2	------	1	8	2	------	1	8	2	------	1
6 segment	20	3	1	1	21	3	1	1	21	3	1	1	21	2	1	1
Second leg:																
1 segment	1	------	------	------	1	------	------	------	1	------	------	------	1	------	------	------
2 segment	2	------	------	------	2	------	------	------	2	------	------	------	2	------	------	------
3 segment	4	------	------	------	4	------	------	------	4	------	------	------	4	------	------	------
4 segment	3	1	------	------	3	1	------	------	3	1	------	------	3	1	------	------
5 segment	6	2	------	------	6	2	------	------	6	2	------	------	6+ or 7+	3? 2	------	------
6 segment	17	1	1	1	15–17	1	1	1	15	1	1	1	14	1	1	1

Third leg:																
1 segment	1	----	----	----	1	----	----	----	1	----	----	----	1	----	----	----
2 segment	2	----	----	----	2	----	----	----	2	----	----	----	2	----	----	----
3 segment	3	----	----	----	3	----	----	----	3	----	----	----	3	----	----	----
4 segment	3	1	----	----	3	1	----	----	3	----	----	----	3	1	----	----
5 segment	6	1	----	----	6	1	----	----	6	1	----	----	6	1	----	----
6 segment	14	([5])	----	----	15	----	----	----	13	([5])	----	----	{12+ or 14}	2?	----	----

[5] One very long.

NUMBER AND KINDS OF HAIRS ON THE LEGS OF TROMBICULIDS OF THE NETHERLANDS INDIES—Continued

Kinds of hairs	Name of species											
	T. oudemansi				*T. acuscutellaris*				*T. densipiliata*			
	Feathered hairs	Bristles	Rod-shaped setae	Spines	Feathered hairs	Bristles	Rod-shaped setae	Spines	Feathered hairs	Bristles	Rod-shaped setae	Spines
First leg:												
1 segment	1	----	----	----	1	----	----	----	1	----	----	----
2 segment	6	----	----	----	1	----	----	----	1	----	----	----
3 segment					5	----	----	----	5	----	----	----
4 segment	4	2	----	1	4	3	----	1	4	2	----	1
5 segment	8	2	----	1	8	2	----	1	8	2	----	1
6 segment	22	3	1	0(1?)	21	3	1	1	22	2	1	1
Second leg:												
1 segment	1	----	----	----	1	----	----	----	1	----	----	----
2 segment	6	----	----	----	2	----	----	----	2	----	----	----
3 segment					4	----	----	----	4	----	----	----
4 segment	3	1	----	----	3	1	----	----	3	1	----	----
5 segment	6	2	----	----	6	2	----	----	6	2	----	----
6 segment	16	1	1	1	16	1	1	1	15	1	1	1
Third leg:												
1 segment	1	----	----	----	1	----	----	----	1	----	----	----
2 segment	4	1	----	----	2	----	----	----	2	----	----	----
3 segment					3	----	----	----	3	----	----	----
4 segment	3	1	----	----	3	1	----	----	3	1	----	----
5 segment	6	1	----	----	6	1	----	----	6	1	----	----
6 segment	14	----	----	----	14	([3])	----	----	14	----	----	----

[3] One very long.

NUMBER AND KINDS OF HAIRS ON THE LEGS OF TROMBICULIDS OF THE NETHERLANDS INDIES—Continued

Kinds of hairs	Name of species											
	T. vandersandei[4]				*T. wichmanni*[4]				*T. pseudo-schüffneri*			
	Feathered hairs	Bristles	Rod-shaped setae	Spines	Feathered hairs	Bristles	Rod-shaped setae	Spines	Feathered hairs	Bristles	Rod-shaped setae	Spines
First leg:												
1 segment	----	----	----	----	----	----	----	----	1	----	----	----
2 segment	----	----	----	----	----	----	----	----	1	----	----	----
3 segment	----	----	----	----	----	----	----	----	5	----	----	----
4 segment	----	1	----	----	----	1	----	----	4	3	----	1
5 segment	----	3	----	----	----	1	1	----	8	2	----	1
6 segment	----	1	1	----	----	1	1	----	18–21	3	1	1
Second leg:												
1 segment	----	----	----	----	----	----	----	----	1	----	----	----
2 segment	----	----	----	----	----	----	----	----	2	----	----	----
3 segment	----	----	----	----	----	----	----	----	4	----	----	----
4 segment	----	1	----	----	----	1	----	----	3	1	----	----
5 segment	----	1	----	----	----	1	1	----	6	2	----	----
6 segment	----	----	1	----	----	1	----	----	16	1	1	1
Third leg:												
1 segment	----	----	----	----	----	----	----	----	1	----	----	----
2 segment	----	----	----	----	----	----	----	----	2	----	----	----
3 segment	----	----	----	----	----	----	----	----	3	----	----	----
4 segment	----	1	----	----	----	1	----	----	3	1	----	----
5 segment	----	1	----	----	----	1	----	----	6	1	----	----
6 segment	----	----	----	----	----	([5])	----	----	14	([5])	----	----

[4] After A. C. OUDEMANS. I suppose that Dr. OUDEMANS had not the intention to give a list of all the plain hairs, but only of those he considered to be a kind of sensory hairs; so we cannot compare his account with ours without further explanation. I have added his figures though, in order to give as much information as possible about the Trombidia, that Dr. OUDEMANS has described already nearly 20 years ago.

[5] One very long.

NUMBER AND KINDS OF HAIRS ON THE LEGS OF TROMBICULIDS OF THE NETHERLANDS INDIES—Continued

Kind of hairs	Name of species											
	T. glabrum				*T. globulare*				*Leeuwenhoekia australiensis*			
	Feathered hairs	Bristles	Rod-shaped setae	Spines	Feathered hairs	Bristles	Rod-shaped setae	Spines	Feathered hairs	Bristles	Rod-shaped setae	Spines
First leg:												
1 segment	1	----	----	----	1	----	----	----	1	----	----	----
2 segment	1	----	----	----	1	----	----	----	6 (2 and 3 segment)	----	----	----
3 segment	5	----	----	----	5	----	----	----				
4 segment	4	2	----	1	4	1	----	1	4	2	----	1
5 segment	8	2	----	1	8	2	----	1	8	2	----	1
6 segment	19	3	1	1	20	3	1	1	23	2	1	1
Second leg:												
1 segment	1	----	----	----	1	----	----	----	1	----	----	----
2 segment	1	----	----	----	2	----	----	----	5 (2 and 3 segment)	----	----	----
3 segment	5	----	----	----	4	----	----	----				
4 segment	3	2	----	1	3	1	----	----	4	1	----	----
5 segment	6	2	----	1	6	2	----	----	6	2	----	----
6 segment	16	1	1	1	17	1	1	1	16	1	1	----
Third leg:												
1 segment	1	----	----	----	1	----	----	----	1	----	----	----
2 segment	[1] 5 (2 and 3 segment)	----	----	----	2	----	----	----	4 (2 and 3 segment)	----	----	----
3 segment					3	----	----	----				
4 segment	3	1	----	----	3	1	----	----	4	1	----	----
5 segment	6	----	----	----	6	1	----	----	[2] 6	1	----	----
6 segment	16	----	----	----	15	----	----	----	[3] 13	---	----	----

[1] One of which is short, thin and possesses only one side hair.

[2] Two of them very long, with only a few side hairs at the base, ending as a whip.

[3] One of them as described for the long hairs of the fifth article.

Appendix G

NOTES ON THE CLIMATOLOGY OF THE NETHERLANDS INDIES

The following notes have been extracted from the rather extensive treatment by Braak (1931) on the climatology of the Netherlands Indies.

Sumatra.—Sumatra has a typical wet, humid, tropical climate. On the west coast the annual rainfall is 110 to 155 inches, although this figure is exceeded in some localities. In general all of coastal Sumatra and its adjacent islands have a very similar climate characterized as very rainy with but traces of the monsoon winds and with a prevalence of local land and sea breezes. In spite of the low wind velocities there is a strong surf on the Indian Ocean, especially outside the small fringing islands. Further inland on the slopes of the Barisan Mountains, which run the length of the island, the rainfall may be more than 150 inches per year.

The east coast has much less rainfall than the west. The annual figures here are about 75 inches, varying with the locality. In the broad plains of middle and south Sumatra rainfall is very evenly distributed and ranges from 75 to 110 inches per year. In the interior at Palembang the monsoons are well developed. Their directions are southeast or northwest depending on the season. The driest month has a rainfall of less than 4 inches only in the extreme southwestern part of the plain. Elsewhere a rainfall of less than 4 inches per month occurs only at Atjeh on the north coast. In the region of Medan

the average of the longest rainless period per month is 18 days. The longest absolute dry period varies from 25 to 35 days depending on the station.

On the east slope of the Barisan Mountains the annual rainfall may be more than 150 inches but is usually much less in the valleys.

The driest region in Sumatra is that around Toba Lake. The high places in North Sumatra are fairly cool with a mean temperature of 17.4° C. at Seribadolok. Here there are strong west winds from May to October.

Borneo.—Borneo has a very uniform tropical climate. In the southeast (Bandjermasin) and in one part of North Borneo (Jesselton) there is a sharp division between the wet and dry seasons, although there is a certain amount of rain throughout the year. There is no marked difference between the lee and windward sides of this island comparable to the conditions in Java and Sumatra, because in Borneo the mountainous country is proportionately much smaller and located in the center of the island. Local land and sea breezes are not well developed along the wooded shores. Yearly variations in temperature are negligible. The humidity is constantly high and cloudy weather is the rule. The location of the mountains allows the shore breezes to pass inland. Rainfall increases in the mountains. Monsoons are most powerful in extreme West Borneo, in the region around the city of Sambas. In the costal region (Panangkat, Montrado, Singkawang) the wind direction is from northwest to southwest in the afternoon, and northeast to southeast in the evening. In the interior valleys local mountain winds are most important.

Java and Madoera.—West Java is a transition between the tropical areas with a homogeneous year around rainfall, and East Java a region with a dry monsoon season. In East Java the east monsoon brings weather

in which the sun shines throughout the day, humidity decreases, and vegetation and rivers dry up.

West Java can be divided into three parts: (1) The hot and relatively dry inland plain around Batavia, (2) the high cool inland plain with moderate rainfall (Bandang, Garut, and Malabar), and (3) the rainy slopes and mountain tops to the north of the coastal plain (table A).

TABLE A.—*Rainfall in Java and Madoera*

Station	Annual (inches)	Minimum month (inches)	Maximum month (inches)
Muaramuntai	61.8	2.2 Sept.	8.0 Mar.
Kuching	159.0	4.1 July	26.6 Jan.
Tawao	74.9	3.2 Apr.	8.6 July 8.7 Nov.
Malabar	102.2	2.4 Aug.	14.0 Feb.
Leinbang	57.5	2.7 July	13.0 Nov.
Sumadra	177.5	4.6 Aug.	23.2 Feb.
Pekalongan	87.0	2.7 Sept.	18.2 Jan.
Gombong	131.0	2.9 Aug.	18.6 Dec.
Cheribon	87.8	0.9 Aug.	17.6 Jan.
Kediri	69.5	0.6 Aug.	12.6 Feb.
Taruna	156.0	8.1 Aug.	18.6 Dec.
Rantepao	154.1	5.2 Aug.	20.4 Apr.
Gorontalo	47.5	1.8 Sept.	5.3 Dec.
Singkang	64.0	2.2 Sept.	6.1 Mar. 9.4 May
Bonthain	53.9	1.0 Sept.	8.2 June
Paloe	21.4	1.3 Dec.	2.7 June
Watapone	98.6	3.1 Sept.	15.0 June

In general, June, July, August, and September are the driest months especially in East Java. November, December, January, and February are in general the wettest months. The difference between the dry and wet seasons are not as distinct in West Java. The dry season on the north coast of Java extends into November.

Celebes.—Rainfall of 150 inches or more per year occurs only in the mountains on the northern peninsula. The Sangihe Islands as well as Una Una, areas in the

mountains of central Celebes, and on the west side of the southwest peninsula have 100 to 150 inches rainfall per year. Most of the island has an annual rainfall of 75 to 120 inches although there are areas with 35 to 75 inches. On Celebes there is considerable variation in the annual distribution of rainfall. In the greater part of Central Celebes where the monsoons exert little influence the heaviest rain occurs from January to March (April in Rantepao). On the north coast of Menado the heaviest rainfall occurs in January (15 to 25 inches). On the west coast at Makassar the month of the heaviest rainfall is also January (20 to 25 inches). The northern part of the west coast has a rainfall maximum in November and December. There are frequently maxima in May in southwest Celebes (Sindjai) and, excepting the west coast, in all South Celebes. In the northwest (Paloe) the maximum occurs in June. On the northern peninsula and also in central Celebes the driest months are August and September.

In northern and eastern parts of Central Celebes and in the eastern part of southeast Celebes (Kendari), the minimum is in October. It is very dry during the east monsoon on the west coastal plain of South Celebes. Palutal is the driest place in the entire archipelago. The west monsoon in January brings rain to the western part of South Celebes. In general, temperatures are uniform throughout the year.

Lesser Soenda and Timor.—The annual rainfall in these islands is much less than in the remainder of the archipelago because of the dry season which occurs during the east monsoon. Annual rainfall in excess of 75 inches occurs only in the heights of Southern Bali and in the mountains of Flores. Most stations have 35 to 75 inches. The east coast of Lombok, the north coast of Soemba, and the north coast of Flores have less than

35 inches per year. In general the driest areas in the Lesser Soenda are the north coasts of the southern row of islands. Some have as little at 0.2 inch rainfall during the driest month. The south coast of Timor has 0.5 inch in August and 0.5 inch in September. Soemba, Saroe, Roti, and Timor have in their nonvolcanic areas a typical savannah flora, quite uncommon in the tropics. The highest temperatures and the lowest amount of cloudiness occur in the months of October and November in the Lesser Soenda Islands. The small plateau of Badjawa in Flores (3,750 feet) has a mean annual temperature of 19° C.

Molukkas.—These islands lie east of the region of the east monsoon dry seasons and are wetter than Celebes at this time of the year. The average rainfall is 75 to 100 inches although south Saparoea and Ambon (140 inches) are exceptions. The mountains as well as the monsoon winds exert considerable influence on the rainfall. For instance, in Ceram, Wahai on the north coast has three times as much rain in January and February as does Amahai on the south coast during the same period; in September the relation is reversed.

There is no dry season. Temperatures are uniform throughout the year (table B).

TABLE B.—*Rainfall in Molukkas*

Station	Annual (inches)	Minimum month (inches)	Maximum month (inches)
Aloe	79.5	0.5 Sept.	17.1 Jan.
Tondano	74.8	2.9 Aug.	8.3 Apr. 8.1 Nov.
Tabanan	105.1	4.0 Sept.	15.1 Jan.
Ende	45.7	0.8 Aug.	6.7 Dec., Jan., Feb.
Wahai	85.6	3.2 Aug.	16.6 Feb.
Amahai	106.3	3.9 Nov.–Dec.	16.9 July
Banda	104.7	4.3 Aug.	15.4 May
Ternate	86.2	4.0 Aug.	9.3 May
Serwaroe	48.4	0.4 Aug.–Sept.	8.7 Apr.
Saumlakki	66.5	0.3 Sept.	10.3 Jan.

Kei and Aroe Islands.—The general rule in this group of islands is an increase in rainfall from west to east. Serwaroe on Leti has 45 inches per year. Saumlakki on Jamdena has 65 inches per year while Tual and Dobo have more than 80 inches. The dryness of the east monsoon is much less at Tual and Dobo than at Saumlakki. The rainfall of the driest months is slightly greater than during the driest months on Timor.

New Guinea.—Although the monsoon winds are well developed over the water surrounding New Guinea, in general they exert little effect on the climate of New Guinea. An exception is the broad lowland between the Digoel River and the south coast in southeast Dutch New Guinea over which both the southeast and northwest monsoons are well marked. Rainfall increases eastward from a line between Celebes and the Molukkas and east of Timor. The west monsoon (northwest) brings rain and high temperatures to southeast Dutch New Guinea, whereas the east monsoon is drier and cooler. The rest of southern Dutch New Guinea, excepting a small coastal area, has its maximum rainfall from May to September. From June to August temperatures are relatively low (23° to 24° C.). The mountains in the interior may have an annual rainfall of 250 to 325 inches annually.

TABLE C.—*Rainfall in New Guinea*

Station	Annual (inches)	Minimum month (inches)	Maximum month (inches)
Merauke	60.6	0.9 Aug.	10.4 Mar.
Fak-Fak	112.1	8.3 Aug. 8.0 Dec.	13.1 May
Jende	164.0	9.5 July	16.8 Feb.
Servei	117.0	7.1 July	14.2 Feb.
Fr. Wilhelmshaven	108.2	4.0 July	13.4 Apr.
Sleptrarrent	118.0	2.7 Aug.	16.3 Jan.
Finschaven	130.0	2.7 June	18.2 Aug.
Deinzerhohe	204.0	7.5 Feb.	27.5 June
Namane	106.1	6.6 Oct.	12.2 Mar.
Peterhafen	128.6	3.9 Aug.	19.1 Mar.

In western Dutch New Guinea the south coast is cooled during the east monsoon; the wind is stronger than during the west monsoons. The climate in general is warm and rainy. Highest temperatures are recorded in October and November with the lowest occurring in January and February although there is only 0.8° C. difference between the means of the warmest and coolest months. The difference between the mean relative humidity of the most humid month (December, 90 percent) and the least humid month (May, 85 percent) is 5 percent. The minimum rainfall is in August.

The southeast monsoon is not completely stopped by the mountains since its effects are observed in the Geelvink Bay Region. With the beginning of the southeast monsoon, known as *wam-braw* there is an increase in temperature and the air becomes drier. *Wam-braw* usually blows in periods of 4 to 8 days with slight decreases at night. The strength of the wind is sufficient to prevent the use of native boats. On Japen (off the northwest coast) the greatest rainfall occurs in February; the least in July.

Along the northern cost of Dutch New Guinea the west monsoon is strongest. There are no reliable rainfall data for this area although the annual figure is probably 80 to 125 inches. The warmest months are October and November. In the level country of the upper Mamberamo and Idenburg Rivers the annual rainfall is 125 to 175 inches.

The snow line in the mountains of New Guinea is about 14,000 feet.

Appendix H

INTERMEDIATE HOSTS OF TREMATODE PARASITES OF MAN IN THE SOUTHWEST PACIFIC

Dr. Paul Bartsch

Curator of Mollusks and Cenozoic Invertebrates
U. S. National Museum

Trematode worms, parasitic in man, constitute an abundant menace to human health in the South Pacific area. No less than 21 species are known from the region. The importance and abundance of some of these parasites becomes at once apparent by Faust's estimate that China alone has 100,000,000 inhabitants suffering from schistosomiasis.

The adult worms of the different species seek different parts of the human body for their activities, some choosing blood vessels, others the lungs and still others the digestive tract or liver.

The group as a whole, as far as known, has one characteristic in common in its life history, namely, that the early part of the life history of these parasites requires a molluscan (snail) intermediate host in which the young after hatching may find a suitable habitat and nourishment for their further, rather complicated development through sporocyst and redia stages to cercaria in which phase they leave the snail and become the infective agent for man.

Some trematodes are not content with one intermediate host, but have a second, which may be fish or crustacean.

All the intermediate hosts here mentioned are fresh-water mollusks, living in streams, ditches, pools, or lakes. Practically all are shallow-water forms, frequenting the margins of these bodies of water. Some even are amphibious, i. e., they may crawl out upon the wet land margins of the water. In sun-exposed places they may seek the shade of the aquatic vegetation.

Most of the species are small. To gather the smaller forms it may become necessary to sift some of the mud on the water's edge; a fly screen mesh will be fine enough. Or, one may take a burlap sack and sew it to a hoop and use this for scraping up mud and vegetable detritus, washing the finer silt through the sack and examining the residue in the bag for mollusks.

The living mollusks can be placed in glass jars; fruit jars will answer. These should not be placed in direct sunlight, but should have ample light. If they prove infected, the cercariae will, when they reach the proper stage of development, escape from the mollusks and can readily be seen as minute free-swimming animals when one holds the jar up against the light.

In plate 1, I have figured representations of most of the genera of mollusks that are known to have served as intermediate hosts for various species of trematodes in the Southwest Pacific. The list of explanations tells which. I have avoided figuring all the species since I believe that is not necessary.

It is very desirable, however, to have representatives of the freshwater mollusks from as many places as possible sent to the Division of Mollusks, U. S. National Museum, Washington, D. C., for positive determination, for comparatively little of the fauna of the South Sea Islands has been exhaustively studied. Every sending, therefore, will be a decided contribution to our knowledge. It is desirable to have some specimens preserved with the animal

for anatomic study. This can be readily done by dropping them in 70 percent alcohol. The amount of alcohol should be ten times the bulk of specimens.

Empty shells or shells with the animal dried in them are also acceptable. *Locality labels* with the specimens are *absolutely necessary* and if it has been observed that certain species are serving as intermediate hosts this fact should be mentioned on the label.

A determination of the pH of the water from which mollusks have been obtained may help in suggesting control measures. Schistosome intermediate hosts appear to need a slightly acid habitat, which can be changed to an alkaline condition by strewing crushed limestone along the margin of bodies of water. This in turn produces an undesirable ecologic condition that will eliminate the mollusk. In some other conditions copper sulphate has been found a good control agent. Much desirable experimenting is needed in this direction.

Plate 1 (Appendix H). Illustrating molluscan intermediate hosts of trematodes (figures 6, 7, 8, 9, 28, 29, are 0.6 natural size; figures 15, 16, 17, 18, 19, × 1.5).

Explanation of Plate 1 (Appendix H)

1. *Digoniostoma robusta* H. Adams.
2. *Katayama nosophora* Robson.
3. *Oncomelania hupensis* Gredler.
4. *Schistosomophora quadrasi* Möllendorff.
5. *Alocinma longicornis* Benson.
6. *Tarebia obliquigranosa* E. A. Smith.
7. *Melanoides tuberculatus* Müller.
8. *Wanga nodiperda connectens* Martens.
9. *Semisulcospira libertina* Gould.
10. *Parafossarulus manchouricus* Bourguignat
11. *Wattebledia crosseana* Wattebled.
12. *Bulimus misellus* Gredler.
13. *Stenothyra divalis* Gould.
14. *Fairbankia parva* Lea.
15. *Lymnaea javanica* Mousson.
16. *Fossaria ollula* Gould.
17. *Myxas papyracea* Tate.
18. *Physastra* (*Ameria*) *carinata* H. Adams.
19. *Physastra sumatrana* Martens.

20–21. *Gyraulus chinensis* Dunker.
22–23. *Segmentina hemisphaerula* Benson.
24–25. *Hippeutis cantori* Benson.
26–27. *Indoplanorbis exustus* Deshayes.

28. *Pila conica* Gray.
29. *Viviparus javanicus* Busch.

Genera of mollusks which have served as intermediate hosts for trematodes:

Katayama *Oncomelania* *Schistosomophora*	Intermediate hosts of *Schistosoma japonicum.*
Fossaria	Intermediate host of *Fasciola hepatica* and *F. gigantea.*
Segmentina *Gyraulus* *Hippeutis*	Intermediate hosts of *Fasciolopsis buski.*
Gyraulus *Lymnaea* *Viviparus* *Pila*	Intermediate hosts of *Echinostoma ilocanum.*
Lymnaea *Indoplanorbis*	Intermediate hosts of *Echinostoma malayanum.*
Lymnaea *Physastra* *Viviparus* *Segmentina*	Intermediate hosts of *Echinostoma revolutum.*
Gyraulis *Viviparus*	Intermediate hosts of *Echinostoma lindoensis.*
Parafossarulus	Intermediate host of *Echinochasmus perfoliatus.*
Semisulcospira	Intermediate host of *Metagonimus yokogawai.*
Bulimus	Intermediate host of *Opisthorchis felineus.*
Parafossarulus *Bulimus* *Alocinma*	Intermediate hosts of *Clonorchis sinensis.*
Semisulcospira *Wanga* *Tarebia* *Melanoides*	Intermediate hosts of *Paragonimus westermani.*

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